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LINEAR MEASUREMENT CONCEPTS OF BILINGUAL AND MONOLINGUAL CHILDREN

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "Linear Measurement Concepts of Bilingual and Monolingual Children", by Werner Walter Liedtke in partial fulfilment of the requirements for the degree of Master of Education.

ABSTRACT

The purpose of this study was to select one unique experience, and test for its effects on the formation of certain concepts. Bilingualism, or the ability to speak two languages at a very early age was chosen to represent such an experience. A test on concepts of linear measurement was used as the main instrument in the study. The test consisted of six subtests and they dealt with the following aspects of linear measurement:

(1) reconstructing relations of distance,
(2) conservation of length,
(3) conservation of length with a change of position,
(4) conservation of length with distortion of shape,
(5) measurement of length, and
(6) subdividing a straight line.

Two samples were selected for the investigation. One sample consisted of fifty monolingual children, and the other of fifty bilingual children enrolled in grade one in schools of the Edmonton Separate School System.

The 'Concepts of Linear Measurement Test' was administered individually to each subject during the month of May, 1968. To control for as many variables in the

data analysis as possible, the additional data collected included information about each subject's sex, birth date, kindergarten attendance, intelligence and socio-economic status.

The tests were scored, and multiple-linear regression analysis was used to compare the means for the two samples. The most important findings of the study were as follows:

(1) The bilingual children were more advanced in their understanding of the concepts of linear measurement than the monolingual children.

(2) The concept of conservation of length was developed to a greater extent in the bilingual children than in the monolingual children.

(3) The bilingual children demonstrated a greater ability to make linear measurements than the monolingual children.

(4) Of all the independent variables considered, only intelligence was found to be a significant factor in predicting scores on the 'Concepts of Linear Measurement Test'.

The study is concluded with implications for educational practice and suggestions for further research.

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THE PROBLEM, ITS NATURE AND SIGNIFICANCE

I. THE PROBLEM

The problem of concept formation is one of major importance to educators. Knowing how concepts and logical thought develop is the best guide in preparing and presenting meaningful learning experiences for children. Their needs can only be properly met once the thought processes and the growth of their understanding are understood.

Perhaps the greatest quantity of work in the field of concept formation has been conducted by the Swiss psychologist Jean Piaget. He has concerned himself not only with the learner, but also with the substance to be learned and its structure or logical organization. Piaget set himself the task of investigating empirically the basis for man's conception of the real external world. With his ingenuous methods and experiments he has probed into the growth of children's concepts in a variety of areas. One of these areas deals with the child's conception of geometry. In his book, Piaget (1960) makes brilliant suggestions as to how concepts develop out of simple behavior patterns, and how a basic repertoire of geometric concepts is formed.

Piaget's theory and the results of his investigation

can be of great value to educators. They provide a guide to the experiences necessary before certain concepts are formed or acquired. His method is valuable in that it presents a way of evaluating an individual's stage of development.

Many programs in the elementary school have been recently revised. Their effectiveness will depend on whether they are related to the way children learn and develop. More specifically, they should relate to the appropriate stage of development for each child. Bruner's frequently quoted hypothesis 'that any subject can be taught effectively in some intellectually honest form to any child at any stage of development' (Bruner, 1960, p. 33) implies that children must be considered individually. Within any one group, even if children are of the same chronological age, they differ greatly. They are different since development at any one stage is a result of many factors. In Piaget's theory there are four contributing forces. They are: maturation, experience, socialization and equilibration. Intellectual development, according to Piaget, is the result of all four.

Almy (1966) points out that experience is always necessary for intellectual development, and Piaget and his collaborators agree with this. However, the latter cautiously point out that it is not the only source. Nevertheless, experience and social interaction are the

main cultural forces responsible for creating individuals that differ so greatly and develop at different rates.

Adler (1966) in commenting on proposed revisions of the arithmetic program, such as the Cambridge Report (1963), concludes that acceleration of learning is not ruled out as impossible by Piaget's theory of stages in the development of thinking. At least two of the contributing factors, the experience acquired in interaction with the physical environment and the influence of the social milieu, are subject to our control since they are cultural rather than genetic.

Piaget's theory and his investigations help us realize that children must assimilate more and more experience in order to make valid generalizations later. His books on number (1952) and geometry (1960) help us to see how long a process the development of mathematical ideas is and how very much it depends on the opportunity to manipulate concrete materials.

The question arises whether there exist other experiences that are beneficial to concept formation and mental development in general. Which experiences are especially helpful in the acquisition of concepts? Do children who are advanced or "above average" have some unique experiences that speed up their development?

One way to discover elements and experiences that are essential and favourable to concept formation would

be to isolate certain relevant factors, present concepts in teaching situations, and determine the value of each of the factors. The above procedure has been successfully tried by a few investigators. (Lefrancois, 1966; Towler, 1966).

According to Piaget, conservation or the awareness of invariance, represents one of the most important components in the transition from intuitive thought to concrete operational thought. Conservation is an intellectual ability that enables the child to interpret his environment more realistically. By testing for the concept of conservation in any particular area a close estimate of a child's stage or level of development can be found.

II. PURPOSE AND SIGNIFICANCE OF THE STUDY

The purpose of this study is to isolate a unique experience and test for its effects on concept formation. It is assumed here that a child who learns two languages at an early age is exposed to an experience that differs greatly when compared to a child who learns only one language. The experience is unique in that in most of these cases the children learn two names for every object. They are constantly hearing the same things referred to by different words. This in turn implies a rather unique interaction with the adults or parents. The bilingual's

environment appears to be more complex and goal-oriented at an early age. Many of their experiences will be of a wide range since they are related to two cultures and not just one. This study will attempt to determine whether the ability to speak two languages is detrimental or beneficial to children in the acquisition of certain concepts.

A test of concept formation will be chosen from the book, Child's Conception of Geometry, (Piaget, 1960), consisting of six subtests. All of the subtests will deal with concepts of linear measurement, and will represent a series of "sub-concepts" such as: judgement of distance, conservation of length, subdivision and construction of a unit. These represent some of the more important aspects of the basic concepts of linear measurement. They are dependent on each other and are acquired in a definite sequence. Thus, a certain score on the test reveals how far the concept is advanced and gives some indication of the developmental stage of the subject.

The study is an attempt to find the answer for the following questions: Does learning a second language at an early age have any favourable effects? Is it a beneficial or a detrimental experience? Can it be demonstrated that there is a link between linguistic and cultural experiences on the one hand and concept formation on the other? What factors are important in the development of concepts?

III. THE NULL HYPOTHESES

The following hypotheses will be tested:

Hypothesis 1: When adjustments are made for differences in age, kindergarten attendance, sex, intelligence, and socio-economic status, monolingual and bilingual children do not differ in their understanding of linear measurement concepts.

Hypothesis 2: When adjustments are made for differences in age, kindergarten attendance, sex, intelligence, and socio-economic status, monolingual and bilingual children do not differ in their ability to conserve length.

Hypothesis 3: When adjustments are made for differences in age, kindergarten attendance, sex, intelligence, and socio-economic status, monolingual and bilingual children do not differ in their ability to measure length.

To consider other factors that could play a role in the development of concepts the following hypotheses were designed.

Hypothesis 4: Age is not a factor in predicting a child's ability to understand the concepts of linear measurement.

Hypothesis 5: Kindergarten attendance is not a factor in predicting a child's ability to understand the

concepts of linear measurement.

<u>Hypothesis</u> <u>6</u>: Sex is not a factor in predicting a child's ability to understand the concepts of linear measurement.

<u>Hypothesis</u> <u>7</u>: Intelligence is not a factor in predicting a child's ability to understand the concepts of linear measurement.

<u>Hypothesis</u> <u>8</u>: Socio-economic status is not a factor in predicting a child's ability to understand the concepts of linear measurement.

In order to test the hypotheses, a test on concepts of linear measurement was designed and administered to two samples. One sample consisted of fifty monolingual grade one children, and the other of fifty bilingual grade one children.

For the major hypotheses, one to three, the means for the two samples on the total test (Concepts of Linear Measurement), part one of the test (Conservation), and part two of the test (Measurement) were compared. For the secondary hypotheses, four to eight, the monolingual and bilingual children were considered as one sample. All of the hypotheses were tested at the .05 level of significance.

IV. DEFINITIONS OF TERMS

Concept -- is a complex system of responses in terms of which basic response patterns are organized.

Measurement -- is a process of associating with some feature of the world of experience a number which describes this feature in terms of some unit.

Attainment of the Concepts of Linear Measurement -- is based on the evaluation of the performance on the "Concepts of Linear Measurement Test".

Conservation -- refers to the mathematical or physical idea that properties of nature remain invariant under certain changes and transformations.

Monolingual -- refers to a person who possesses the ability to communicate in one language and has no functional knowledge of a second language.

Bilingual -- refers to a person who possesses the ability to communicate meaningfully in two languages, is capable of switching from one to the other, and lives in a home where two languages are used.

Intelligence -- refers to the score obtained by the subjects on the S.R.A. - Primary Mental Abilities Test administered during the month of April, 1968.

Socio-economic Status -- refers to a number that was obtained by matching the father's occupation with a scale designed by Blishen (1961).

V. LIMITATIONS

In reading the report and interpreting the data the following limitations should be kept in mind:

(1) The sample of one hundred grade one pupils represents six schools of the Edmonton Separate School System.

(2) Fifty subjects represent the urban monolingual grade one population.

(3) Fifty subjects represent the urban bilingual grade one population.

(4) No test was administered to determine a degree of bilingualism.

(5) It was assumed that the "Concepts of Linear Measurement Test" measures the development of a concept. No measure of validity was obtained, only an estimate of reliability was calculated.

(6) For the purpose of this study, it was assumed that there was no difference in competence of the teachers of the bilingual children and teachers of the monolingual children.

VI. OUTLINE OF THE CHAPTERS TO FOLLOW

In Chapter II the development and nature of thought as described by Jean Piaget is discussed. Some related studies are reviewed, and Piaget's experiments on conservation and measurement of length are summarized. Also

included are a discussion on bilingualism and a review of some basic studies.

In Chapter III a detailed description of the sample, instrumentation, testing procedures, and statistical analysis used by the investigator is presented.

In Chapter IV the data are analyzed and the findings of the experiment are reported.

Finally, the investigation is summarized in Chapter V and some recommendations for further research are made.

CHAPTER II

THEORETICAL FRAMEWORK AND RELATED LITERATURE

I. INTRODUCTION

Before children understand space relations, they must see themselves as but one moving object among others situated in a framework of fixed references. The construction of a reference system is essential for the conception of geometry, or the construction of Euclidean space. The sequence of development is a slow and involved developmental process, and is completed by the time a child reaches the age of eleven or twelve. The complete frame of reference is in fact the culminating point of the entire development of Euclidean space.

Such notions as change of position, ideas of measurement, and conservation of length and distance mark the beginning of the construction of Euclidean space. The ability to measure represents a major achievement for the child.

Measurement can be defined as "a process of associating with some feature of the world of experience a number which describes this feature in terms of some unit." (Pelletier, 1966, p. 7) Numbers are used to express the magnitude of an object's property.

> True measurement becomes possible when a part belonging to a whole is compared with the remainder by successive superposition of

> the part on the whole. This is known as <u>unit iteration</u> and may be accomplished with the part itself or with a common measure used transitively. Such measurement represents the fusion of the operation of <u>subdivision</u> (of length or area) and change of <u>position</u> (in space) into a single operation. (Beilin and Franklin, 1962, p. 607)

Experiments and tests by Piaget, his collaborators, and other investigators show that a child's level of development places a limit on what he may acquire by virtue of experience or training at any particular time. The child must assimilate more and more experience in order to be able to make valid generalizations later.

II. JEAN PIAGET: DEVELOPMENT AND NATURE OF THOUGHT

Jean Piaget has dedicated the major part of his life to probing into the development of thought in children. His main interest lies in the growth of human capacity for knowledge, or more specifically, the development of logical, mathematical, and scientific thought. He has created an ingeneous plan for a systematic experimental enquiry into the processes and stages of intellectual development in children, from the beginning to maturity. The results of his enquiry and testing form a large part of his developmental theory. According to his tests and interviews children are capable of adult thought at the age of eleven or twelve, when they have reached the stage of formal operations.

The nature of thought prior to maturity is described

by Piaget in terms of what children cannot do. The characteristics of these limitations break the period of development into three distinct stages: the sensori-motor (0-2), pre-operational (2-7), and concrete operational stage (7-12).

Piaget, and his work, is often criticized for the methods he used, and for attaching ages to his stages. However, replications of his studies by various investigators indicated similar results when applied to fifty per cent or seventy-five per cent of the children.

> A persistent and overriding interest in the area of intelligence is a salient feature distinguishing Piaget's work from that of most child psychologists. (Flavell, 1963, p. 16)

Intelligence is conceived of as originating in a biological substrate with a limiting anatomical structure. (Specific Heredity) The biological structures condition what an individual may perceive. However, also inherited are biological "anlagen" that permit a person to overcome these limitations. "Thus cognitive structures are not inherited, they come into being only in the course of development." (Flavell,1963, p. 43) Intelligence then, is a way of functioning with the environment. The ability to function and its degree of effectiveness depends on how well an individual adapts to the environment. The ability to cope with the environment is increased by incorporating objects of the environment (assimilation), and changing the ways of acting or behavior as a result

of environmental demands (accommodation). "One way in which these two processes are interrelated is that the organism must to some degree assimilate a new situation before it can accommodate to it." (Baldwin, 1967, p. 176) Assimilation and accommodation permit the organism to make cognitive progress. From the operation of these, structural units called schemas are born and developed. In infancy looking at an object, handling the object, and listening to a sound are actions that form a schema. The "schema" is a cognitive structure which has reference to a class of similar action sequences. It is a complex concept encompassing both overt motor behavior patterns and internalized thought processes. (Flavell, 1963, pp. 52-53; Baldwin, 1967, p. 175)

The schema refers to the structure common to all those acts that an individual considers to be equivalent. These schemas are mobile. A child of two can grasp and pick up objects. He adjusts easily to the particular orientation of objects, be they string, blocks, marbles, or sticks. The mobility of the schemas enables the child to adapt the prehension to different circumstances. Schemas expand, become discriminative and co-ordinate to one another. As a result the child becomes capable of intentional activities. New behavior is learned by applying, modifying, or combining schemas, and using them simultaneously or sequentially. The modification of the structural schemas

results in intellectual functioning. External disturbances and organism-environment exchanges result in adaptation. If assimilation and accommodation are in balance or in equilibrium during the process, intellectual adaptation takes place.

An idea central to the development of knowledge is that of an operation or interiorized action. "At first the child does little more than replicate in his head simple concrete action sequences he has just performed or is about to perform." (Flavell, 1963, p. 82) Therefore, to begin with, an image is not a conceptual but a concrete representation. However, this image is an internal act or an internalized imitation of a sensorimotor action. The first signs of symbolic behavior, or symbolic schemas, become evident in the processes of imitation and play. The child uses a concrete schema to represent something else. He experiments and adapts to new situations. His cognitive actions become more abstract and broader in range. Thus cognitive progress is a result of continually extending accommodatory acts to new and different features of the environment. These features are assimilated into existing meaning structures and change them to some degree. This creates the possibility for further accommodating extensions. In this way, transformations are interpreted and the state of things is understood.

Learning then, is provoked by situations, and

Piaget believes that each element of learning occurs as a function of total development. A particular social environment is indispensible for the realization of an individual's mental possibilities. However, social environment by itself is not the only contributing factor. The formation and development of cognitive structures is a result of many factors.

The forces Piaget hypothesizes to explain the process of development are: maturation, experience with the environment, socialization, and the process of equilibration. The internal factor of maturation refers to the gradual development of the dynamic structures. Maturation of the central nervous system opens up possibilities but is not sufficient in itself to realize them. The order of succession is constant, but the age at which these structures appear is relevant to the environment.

> The genetic development seems to follow a general law of the same type as the laws of organic growth. However, ... the age of realization can not be fixed absolutely; it is always relative to the environment. (Inhelder, 1963, p. 39)

Experience with the environment is an external factor necessary for the construction of dynamic structures. However, experience by itself, does not sufficiently describe the process. Piaget (1967, pp. 273-274) gives three reasons for its insufficiency.

Many actions or ideas are abstract and cannot be perceived or measured. They are deductions and not part of experience. The notion of "substance", for example, cannot be acquired by merely manipulating or handling concrete objects.

Adult reasoning, or thought, at the formal operational level is governed or restricted by laws of logic. This logical structure cannot stem from experience alone. Logical structure is not "learned" or discovered, but is the result of other prelogical structures. Experience can lead to the acquisition of conservation of weight because of its physical character. However, acquiring the transitivity of the relationship of the weight A=C, if A=B and B=C is more difficult, because it is built on other more elementary logical structures or operations such as the ability to classify and seriate.

Finally, Piaget distinguishes between two kinds of experience. Physical experience leads to abstraction directly from the objects. When faced with two objects made of the same substance, a child can easily discover that greater volume implies greater weight. Logico-mathematical experience leads to abstractions from actions between objects. The manipulation of concrete objects can lead a child to discover that two groups of four equal four groups of two, and that the sum is independent of the order of counting. The discovery is a result of abstracting

from the action, rather than the objects.

Social interaction, the second external factor, includes educative and social transmissions. It is the result of explicit and implicit teaching of the child by other people in his environment. This factor, too, is not sufficient for the construction of dynamic structures. There are certain structures which cannot be taught. Readiness depends on preliminary structures and these are related to the stage of the development. It would be impossible to teach the conservation of number to a three year old. He does not possess any dynamic structures, not even at the concrete level, that would enable him to assimilate this concept.

> Practically, one would have to rely on three principal factors in order to explain the facts of development: maturation, physical experience, and social interaction. But in this particular case none of these three suffice to furnish us with the desired explanation -- not even the three together. (Piaget, 1967, p. 272)

The fourth factor, equilibration, intervenes in the interaction between the external (experience, social interaction) and internal factors (maturation). In assimilating experience (physical and logico-mathematical), the process of equilibration serves as a self-regulating and self-correcting device. It is set in motion whenever a child's belief system develops far enough to begin to contain self-contradictions. "The equilibrium between assimilation and accommodation compensates for exterior

disturbances through activities of the subject orientated in the contrary direction of these disturbances." (Piaget, 1967, p. 274) In this way the subject's actions are co-ordinated. Contradictions and incoherency are avoided. The child's ideas are harmonized with one another. As a result the child tends to reorganize his beliefs into a coherent, harmonious and equilibrated system.

> In this sense of constant self-regulation and self-correction the equilibration factor is fundamental. The equilibration is to be established among actions and operations (which are simply mental or internalized actions not physically performed); it is not an imposed equilibrium of physical forces.... This constant equilibration, moreover, reveals a remarkable continuity between cognitive functions and organic functions. (Piaget in Almy (foreword), 1966, p. VI)

The process of equilibration determines, at each stage of development, the best forms of adaptation compatible with maturation, experience, and influence of the social milieu. Equilibration enables the child to handle his beliefs and knowledge and organize them into some kind of a system.

In describing the child's development of operational structures, Piaget distinguishes four distinct stages. During the sensory-motor stage innate reflexes are modified and expanded through experience. New schemas are acquired by extending the reflex patterns. New behavior is a result of random movement. Since schemas are mobile and flexible the child learns to put together a set of schemas

in a means-end relationship. Thus he is able to vary intentionally his behavior and produce new behavior patterns. The end of the stage is characterized by the possibility of mental representation. (Baldwin, 1967, pp. 193-220) The end of the period represents the highest degree of intelligence possible without the use of language or symbolic representation.

The pre-operational period begins with the acquisition of representative thought. The child begins to experience mental pictures of the external world and of his own actions. These schemas are the first signs of conceptual thinking. However, the nature of thought throughout this period is characterized by many limitations. Egocentrism is one of the principal ones. The child is unable to take the role of another person. He cannot justify his reasoning and is unable to look for contradictions in his logic. He is able to think, but unable to think about his own thinking. Another characteristic of the period is centration and decentration. When considering an object the child centers on a single feature. He is unable to decenter or take into account others, or all relevant features. If the child sees some liquid being poured out of one glass into a taller and thinner glass, the "amount" of liquid becomes more. He is unable to consider the changes in height and width at the same time, and therefore fails to recognize that they compliment each

other. This inability results in distorted reasoning. Pre-operational thought cannot comprehend transformations because it is static and immobile. A child easily recognizes equality when presented with two sticks that are the same length. However, once the sticks are staggered, one becomes longer or shorter. He contradicts his previous statement without realizing it.

New concepts cannot be assimilated into the existing structure, and this results in an unstable discontinuous cognitive life. Cognition is a mental experiment, and is a replica of the concrete actions a child participates in. Therefore, thought is very concrete. It is also irreversible. When presented with a sequence of statements or actions, the child is unable to return to the initial premise or statement. The few primitive concepts (preconcepts) the child possesses are linked transductively, and when reasoning he tends simply to juxtapose. (Flavell, 1963, pp. 156-163) A child will conclude that because A is like B in one respect, therefore it must be like B in other respects. For example, a house has a roof and a school has a roof. Therefore, a house is a school. During this period children cannot accommodate things or facts that are not related to their experience. They are unable to abstract, and rely heavily on perception. "Any conclusions are still at the mercy of changes resulting from successive 'centerings'." (Berlyne,

1967, p. 265) One aspect of an object or action is considered while the others, important as they may be, are completely ignored.

Piaget believes that conceptual thought and perception differ and develop independently of each other. Conceptual thought is characterized by many limitations because children at this stage operate mainly on the perceptual level. Perception is a momentary view of a stimulus, and dependence on perception limits the ability to integrate separate experience into a single judgement. Perceptual objects lack invariance. For an adult objects remain unchanged unless something specific changes them. Simply observing, moving, or changing the object's environment does not change its size and shape. However, in perception this invariance does not hold true. Size, shape, and color appear to change under certain transformations or changes of environment.

> In this way thought and perception differ. One can know something is one way, yet perceive it differently. In such cases, the knowledge is usually based upon a broader body of information than is perception, although this broader body of information is somehow not integrable into a perception.... For Piaget, one of the important developments in the child's acquisition of conceptual thought is the gradual appeárance of the effects of previous knowledge upon his thinking. (Baldwin, 1967, p. 224)

This knowledge is based on a broad body of information acquired as a result of maturation, experience, interaction with the environment, and equilibration.

Separate experiences are integrated into a single judgement and objects remain unchanged unless something specifically changes them. Conceptual thought gradually appears and develops during the pre-operational period, but consists largely of isolated cognitive experiences. During this period the child operates on the perceptual and conceptual level. Eventually the conceptual approach becomes more effective and powerful. (Baldwin, 1967, pp. 221-230)

> One of the most important components of the transition from pre-operational to concrete operational thought is the acquisition of various conservations, that is, the cognition that certain properties (quantity, number, length, etc.) remain invariant (are conserved) in the face of certain transformations (displacing objects or object parts in space, sectioning an object into pieces, changing its shape, etc.) (Flavell, 1963, p. 245)

The developmental steps in the acquisition of conservations are roughly the same for the various properties. There exists a stage of non-conservation. This is followed by an intermediate response stage where children alternate between non-conservation and conservation. Children contradict themselves without realizing it. Finally they reach the stage of conservation and the concept becomes part of their intellectual structure.

During the concrete operational stage, logical or "operational" thought emerges. This thought is based on basic concepts that have been organized into coherent systems.

> The concepts which figure in operational thought are called "operations" because they are internalized responses. They grow out of certain overt actions in exactly the same way as images grow out of imitation. (Berlyne, 1967, p. 265)

All the mental actions implied by our common mathematical symbols (+, -, x, ÷, =, <, >) belong to, but do not exhaust, the domain of cognitive operations. Three sorts of operations are basic and of importance. They are the ability to classify, order, and deal with number. Intellectual development is therefore a process of organizing active operations into systems with a definable structure.

Systems of operations are called groupings. These systems display the following mathematical group properties: closure, reversibility (inverse), associativity, and identity. One other property is described as tautology or iteration.

Thus thought is now governed or restricted by the laws of logic. However, limitations are still present. Understanding is limited to actual observation of concrete events in the child's environment. The child is unable to generalize or relate events. A process or method of solving a problem used in one case cannot be freely applied to a similar situation in another setting. He cannot reason deductively. Things are meaningful only if they are related to the child's experience and concrete objects. Complete "decentering" and "reversibility" and the capacity

for abstract thought are acquired at the end of the concrete operational stage. "The complete separation of form from subject matter constitute the beginning of formal logic, and the stage of formal operations and adolescence." (Piaget, 1957, p. 17)

Conservation represents an important step in the development of logical thinking. It represents intellectual potential and according to Piaget (1952, p. 3) it is a necessary condition for all rational activity.

> A correct conservation response implies more than a simple awareness of invariance; it marks the end of the period of intuitive reasoning even as it signals the beginning of the concrete level of operations; but, more important, it is the first evidence of the co-ordinated use of the operations of identity, reversibility, and combinativity -- operations which, together with associativity and tautology or iteration, not only define concrete reasoning, but also serve as the essential elements from which the child's intellectual structure will be constructed. (Lefrancois, 1966, pp. 71-72)

Results from Piaget's tests indicate a definite staggering for the acquisition of various conservations.

> Awareness of the transitive character of equalities for length, weight, and volume appears during different stages of the concrete operational stage. There exists a time lag of several years between the different fields or subject matters. (Piaget, 1957, p. 17)

The age amongst individuals may vary somewhat; however, a definite order seems to be apparent: quantity and number (6-7), mass and length (7-8), area and weight (9-10), and finally volume (11-12). (Piaget, 1957, pp. 16-17).

III. PIAGET-TYPE STUDIES

Piaget's experiments have been duplicated by numerous investigators. Most of these studies have addressed themselves to four main questions: (Almy, 1966, pp. 30-48)

(1) Are the stages of development described by Piaget identifiable in other populations?

Studies from Japan, Britain, Norway, Canada and the United States show that the major stages of development, as outlined by Piaget's theory, are universal and not just applicable to Swiss children. Conservation is a gradual development. There exist periods of non-conservation, perceptual domination, followed by a transitional stage, before conservation is acquired.

(2) Within any given stage are the relationships among underlying abilities similar to those set forth in the theory?

Almy, in reviewing the related literature, states that presently available evidence is not sufficient to draw valid conclusions. The factor analytic approach would have to be used to examine all the abilities and correlations between them.

(3) How is attainment of a particular level of thought related to progress in intellectual development as measured in other ways?

Almy (1966, p. 40) concludes that,

> ... the safest generalization to be made from current evidence regarding the relationship between performance on Piaget tasks and mental ability as measured on other tests is that to some extent brightness pays off.

The crucial factor may be verbal ability. (Almy, 1966, p. 40; Lefrancois, 1966, p. 67) The question arises whether verbal ability is related to socio-economic status. The ability to adjust to an adult's way of organizing, or the ability to handle spatial relationships could also be important.

(4) To what extent is progress from one level of thought to another impeded or facilitated by various kinds of experience, or, more specifically can training accelerate the transition?

Piaget (1964, p. 11) stresses the importance of experience. He considers it the basic factor in the development of cognitive structure. By informally observing and manipulating concrete objects, relationships are discovered and become part of the child's cognitive structure. But, to find out exactly how, and which experiences are most valuable, an experimental training procedure must be used.

A few investigators report some success in teaching the concepts of conservation, even so their methods and approaches differed. Lefrancois (1966) stressed sub-ordinate capabilities and verbalization of performance tasks. Towler (1967) presented crucial aspects of the conservation principle to small groups in his research. However, Sawada

(1966) found that children possess conservation at the non-verbal level a year or more before verbal tests indicate. This could mean that the above, or similar studies, merely taught the subjects to verbalize the concept, since the age difference between their groups and those tested by Piaget and other investigators was not that great. It could be that these subjects just did not "have" the proper language that would help them overcome the pull of their visual perceptions. (Bruner, 1964, 1966) Bruner also points out that the language children use is associated with how well they carry out their tasks. Insight is gained by describing a problem. The ability to say becomes the criterion for learning. If these researchers were able to accelerate the process of mental maturation beyond the verbalization level, the implications are rather significant.

IV. CONSERVATION AND MEASUREMENT OF LENGTH

To demonstrate how children come to understand the concepts of length and measurement, Piaget, Inhelder, and Szeminska (1960, pp. 67-149) have outlined some ingenuous experiments. The topic of Conservation and Measurement of Length is discussed under four main sub-headings: Reconstructing Relations of Distance, Change of Position and Conservation of Length, Conservation and Measurement of Length, and Subdividing a Straight Line.

Reconstructing Relations of Distance. Usually no sharp distinction is made between the concepts of distance and length. Psychologically they point to quite different situations. 'Length' denotes size or distance taken up by an object. 'Distance' refers to linear separation of objects or empty space. The notion of distance is essential to both the development of measuring and viewing spatial relations between objects. Interpreting relations in terms of distance heralds the construction of a co-ordinate system. To find out how children judge distances, the experimenters used two trees or lead figures. These were placed about fifty centimeters apart. The child was asked whether they were "near one another" or "far apart". The setting was then changed. For example, one tree was raised, screens (with and without doors) or a cube were placed between the trees. For each case the child was asked whether the trees were still as "near" or as "far apart" depending on his previous reply. Results from children of different ages (4.2 - 7.10) show three distinct stages: absence of overall distance, recognizing overall distance but not when an object is placed between the trees, and realization that distance between two stationary figures remains invariant and the same in either direction, no matter what is placed between.

Change of Position and Conservation of Length. In one part of the experiment the children were asked to compare

the length of a stick and an undulating thread of plasticine, their endpoints coinciding. For another part they were shown two five centimeter sticks with their extremities facing each other. One of the sticks was then moved forward one or two centimeters. The question asked was, "Are the objects the same length or is one longer than the other?" Children at the age of about seven and upward showed an understanding of conservation, and answered the question correctly. The younger children did not possess a reference system. They were unable to relate the objects, any of their parts and the empty sites.

Conservation and Measurement of Length. Two of the experiments involved distortion of shape. Twelve to sixteen matches were placed end to end in two parallel rows so that their equality was obvious. One row was modified by the introduction of angles, zigzags, or some of the matches were broken. Also, two thirty centimeter strips of paper were used. One of the strips was cut, cut again, and arranged in a variety of ways. The question was always whether the two rows or strips were still the same length. In order to answer the question correctly both subdivision and order or change of position must be considered. Co-ordination between these two came after the age of seven for most subjects.

Another experiment involved measurement of length. Strips of paper were pasted on cardboard in a variety of

linear arrangements. (right, acute, or obtuse angle) The child was asked to compare two of these and verify his answer. Strips of cardboard were available to serve as unstandardized units. Most young children failed to see the necessity for using unit measures. While many of the seven year olds conserved length, the insightful operational fusion between subdivision and change of position was achieved only by eight year olds.

Subdividing a Straight Line. In this experiment the children were asked to locate a segment on a straight line equal to a segment given on another straight line. Beads on strings were used. The setting was changed by staggering the strings, beginning on opposite ends, using strings of different length, or having the strings neither parallel nor in alignment. A blank ruler, two sticks, strips of paper, a pencil and threads were available to measure. Young children failed the task because they neglected to take into account the points of arrival and departure. They saw no need for accurate subdivision. Their measurements were merely visual or manual estimates. Measurement beyond trial and error was not achieved until the age of eight or upward.

From these experiments a certain developmental sequence appears evident. A young child possesses an egocentric distortion of space. He lacks other-role orientation. When asked to look at a visual display and

replicate it, his actions demonstrate lack of a reference system. He can only interpret objects in space in terms of his own perspective. His ability to measure consists of making visual comparisons between endpoints. Change of position makes its first appearance when children attempt to bring perceptual fields together through manual transfer. At a later stage they discover the 'middle term' and use body transfer to imitate the measured object. "Conservation is always the outcome of complimentarity between the two groupings: that of additive subdivision and that of ordered positions and changes of position." (Piaget, 1960, p. 300) Unit iteration and the transitivity of the common term make the acquisition of conservation of length complete.

V. STUDIES ON CONSERVATION OF LENGTH

Lovell (et al., 1962) replicated twelve of Piaget's experiments on geometrical concepts. The subjects were primary school children in England. The results obtained were in close agreement with those of Piaget. Similar age characteristics and stages of development were found. However, it was discovered that some subjects did not appear to pass through the intermediate stages as outlined by Piaget. They proceeded from the visual stage directly to conservation. It also was shown that the least able did not reach the stage of concrete operational thinking. Since all of the subjects attended school and were subjected to measuring and work

with measures, Lovell concluded that many of them measure without fully understanding the nature of the actions they were engaging in. Only one-third of the seven year olds, one-half of the eight year olds, and three-quarters of the nine year olds were at the stage of operational conservation. To the others the ability to subdivide did not imply being able to use homogeneous units. They failed to see length as a 'journey', and interpreted it only in terms of the two endpoints: arrival and departure.

Beilin and Franklin (1962) in part of their experiments with grade one and three subjects, tried to foster basic concepts of measurement and measurement operations through instruction. However, results from the younger children lend support to the view that the child's level of development places a limit on what he may acquire by virtue of experience or training at a particular time. No child achieved operational area measurement in the first grade in spite of training and measurement concept instruction. This implies that experience and the ability to use logic aid one another.

Smedslund (1963) tested one hundred seven subjects age four to ten. He used colored sticks of different length. These were arranged in pairs on cardboard. Strips of paper were used to induce Mueller-Lyer illusion. He found that half of the eight year olds possessed transitivity of length. This supports Piaget's average age of acquisition.

Pelletier (1966) studied grade one children's concepts of linear measurement after they had received formal instruction in a particular arithmetic program for nine months. He compared three programs: Numbers We Need (Brownell and Weaver), Seeing Through Arithmetic (Hartung et al.), and a group instructed by the Cuisenaire Method. The topics of measurement are treated differently in these programs. However, he found no significant difference between the three groups. Many subjects were able to verbalize measurement terms, but they did not comprehend the underlying concepts. The terms 'distance', 'length', and 'measure' were not understood, and many subjects lacked conservation of length.

Piaget's experiments and these studies seem to indicate that:

(1) Measurement concepts appear to develop through continuous stages.

(2) There exists a relatively fixed sequence of development.

(3) Intellectual achievements at any one time are not solely the function of training or experience.

VI. BILINGUALISM

Piaget's theory states that intellectual development proceeds through qualitatively distinct stages that occur in a definite sequence. During each stage the child acquires

the abilities that prepare him for the next stage. As outlined previously, Piaget states that the rate of preparation is determined by four factors: maturation, experience, social interaction, and equilibration. Two of these factors are cultural, rather than genetic. This implies that the sequence of the stages is fixed, but the ages at which they occur is not. Some unique experiences could be beneficial to the intellectual development of the child and enable him to pass through the stages more rapidly.

Some children are brought up in a bilingual home environment. They learn two languages simultaneously at a very early age. Thus they are exposed to an environment that is different, and more complex. Most of them have two "worlds" of experience. Social interaction in Piaget's theory includes implicit and explicit teaching by other people in the environment. Learning two languages, or two symbols for every object, implies a greater degree of explicit teaching. One might assume that a young child learning two languages at the same time is exposed to a greater amount of social interaction when compared to someone his own age just learning one language.

In considering the bilingual individual, Haugen (1961) states that the bilingual suffers in either tongue when judged by highest standards, but he also has insights not granted in quite so vivid a manner to others. He points out that studies involving bilinguals present contradictory

conclusions. One reason for this could be that most studies relied on the results of one test. One intelligence test is too gross a measure to throw much light on the psychological processes of bilingualism.

The standard Intelligence Quotient tests measure only the ability to think convergently, or how to manipulate concepts and reconstruct issues. However, Guilford (1956, 1959) points out that there exist many components of intelligence (there are at least fifty ways of being intelligent). He isolated by means of the experimental application of the method of factor analysis, a general factor and many different specific factors of intelligence. The emergence of an intelligence factor is dependent on the accumulation of experiences. He concludes that every factor can be developed in individuals at least to some extent by learning. That implies that in order to compare two, or a group of individuals, one would have to rely on a battery of tests.

VII. STUDIES ON BILINGUALISM

Peal and Lambert (1962) review studies on bilingualism dating as far back as 1920. The answers to the question whether monolingual and bilingual children differ in intelligence as measured on standardized tests fall into three categories:

(1) Bilingualism has a detrimental effect on intelligence.

(2) There exists no significant difference between the two groups.

(3) Bilingualism has favorable intellectual consequences.

Studies that support the detrimental effect conclude that bilingual children are deprived in certain ways. They are hindered from developing fully in either language (language handicap) and tend to be 'mentally confused'. Some results indicate a better verbal and non-verbal performance for monolinguals, others just found a verbal superiority. Only two studies found favorable effects of bilingualism. A closer analysis of these studies revealed that the conclusions reached by these researchers were based on studies with little internal or external validity. They failed to define mono- and bilingualism, and did not control for socio-economic status. Different age groups were compared, and sex was not controlled. Many researchers failed to consider the educational background of their subjects. In the light of these data, Peal and Lambert constructed the hypothesis that there exists no significant difference between monolinguals and bilinguals, once all the important variables are controlled. They carefully chose all the ten year old bilinguals from six Montreal schools and matched them according to socio-economic status, sex, and age with an equal number of monolinguals. A battery of tests was chosen to test for the effects of bilingualism

on intelligence and school achievement. Factor analysis was used to interpret the results. In comparing the intelligence of bilinguals and monolinguals they found that bilinguals scored significantly higher on all verbal and most non-verbal parts of their tests. On none of the subtests did the monolinguals exceed the bilinguals. Most bilinguals achieved higher grades in school.

The factor analysis revealed that bilinguals have a greater number of separate or independent abilities on which to draw in completing the tests. They have developed more independent abilities and skills at an earlier age through their experiences and their learning of a second language. The structure of their intellect appears to be more diversified than that of monolinguals. Wider experiences, greater mental flexibility, and superior verbal skills and fluency helped them to achieve better in school.

These results seem to indicate that being bilingual does not imply 'mental confusion' or a 'language handicap'. On the contrary, bilingualism explained on the basis of transfer, appears to be a 'language asset'. Peal and Lambert constructed the following hypotheses to explain their results. Bilinguals have two symbols for every object. There appears to be less reliance on the linguistic symbol. This enables them to abstract concepts and relations independent of the actual words. Thought becomes less subject to language. Switching from one language to another

is helpful in symbolic re-organization and makes the bilinguals more flexible. They have a broader experience and come into contact with more types of ideas and situations.

Jacobs (1966) in his study tested the relationship between bilingualism and creativity. He compared a group of monolinguals with three groups of five different linguistic backgrounds. The "Word Meanings" and a "Uses" test were administered. The bilinguals scored considerably higher than the monolinguals. When the subjects were matched according to I.Q. quartiles the difference in scores was still higher. These results seem to indicate that bilinguals exhibit a somewhat greater ability to think divergently, a characteristic not measured on intelligence tests.

One of the few longitudinal studies on bilinguals was done by Leopold. He observed his own children and concludes:

> The most striking effect of bilingualism was a noticeable looseness of the link between the phonetic word and its meaning.... This separation of word and meaning may be considered beneficial because it favors content over form, thinking over verbiage. (Leopold, 1961, p. 358)

This seems to imply that bilinguals learn early to separate the sound of a word from its referent. This enables them to dissociate thought from words. Thus, thinking is not restricted to language.

One of the important contributing factors of development in Piaget's theory is experience. Guilford (1956) concludes that the emergence of an intelligence factor is dependent on the accumulation of experience. From these notions it seems reasonable to propose that factors of intelligence appear at different ages in monolinguals and bilinguals. Their early experiences are quite different and this could imply different effects on intellectual functioning.

Peal and Lambert (1962) review many studies that show bilingualism to have a detrimental effect. Children learning two languages were reported to be 'mentally confused', suffered a 'language handicap', and were intellectually inferior. Many studies showed that bilinguals possessed inferior verbal skills when compared to monolinguals. Since 'brightness' (Almy, 1966) and verbal skills and fluency (Lefrancois, 1966; Bruner, 1966) aid in the acquisition of conservation concepts, the above results imply that a bilingual individual passes through the developmental stages at a slower pace than a monolingual. This in turn would mean a delay in the acquisition of conservation concepts. If then, at any one time a conservation test is administered to monolinguals and bilingual children of the same age, the monolinguals should receive a higher score.

However, Peal and Lambert (1962) point out that the results stated above came from studies with little external

validity. A carefully controlled study by the same authors contradicted much of the existing evidence about bilinguals. They found bilinguals to be intellectually superior. The bilinguals possessed greater verbal skills, exhibited greater mental flexibility, and they were more facile at concept formation. All these would indicate that the bilingual child acquires the concepts of conservation before the monolingual. This implies that speaking two languages is beneficial to children in the acquisition of conservation concepts and that bilingualism has favorable effects on intellectual functioning.

CHAPTER III

THE EXPERIMENTAL DESIGN

This chapter contains an explanation of the selection of the two samples, a description of the instrumentation, and a discussion of the testing, scoring, and statistical procedures used to analyze the results of the study.

I. THE SAMPLES

The Edmonton Separate School Board office suggested the names of six schools for the selection of the two samples necessary for this study. The principals from these schools made nine grade one classrooms available.

From six of these classrooms the monolingual sample was chosen. There were 137 students in these rooms who were 'monolingual', and a table of random numbers (Kenney, 1963) was used to select 50. The distribution of age and sex for the monolingual sample is shown in Table I.

The bilingual sample was chosen from the three remaining grade one classrooms. According to the teachers, sixty-two children in these classes were 'bilingual', a number considered too small for random selection. Since this was the case all the bilinguals from two of the classrooms were included in the study, and eight more from

TABLE I

DISTRIBUTION OF AGE AND SEX FOR MONOLINGUAL SAMPLE

Age in Months	Male	Female	Total
98 - 101	0	1	1
94 - 97	1	0	1
90 - 93	0	0	0
86 - 89	4	6	10
82 - 85	9	5	14
78 - 81	7	8	15
74 - 77	4	5	9
Total	25	25	50

the third to complete a sample of fifty subjects. The distribution of age and sex for the bilingual sample is shown in Table II.

TABLE II

DISTRIBUTION OF AGE AND SEX FOR BILINGUAL SAMPLE

Age in Months	Male	Female	Total
86 - 89	5	4	9
82 - 85	10	10	20
78 - 81	6	6	12
74 - 77	4	5	9
Total	25	25	50

The bilingual children received instruction in English and French, but the monolingual subjects were taught solely in English. The subjects of both samples were instructed from the same arithmetic text: Seeing Through Arithmetic 1 (Hartung, *et al.*)

II. INSTRUMENTATION

The data such as the child's age, intelligence score, and father's occupation were obtained from the student's school record. Sex and kindergarten or play-school attendance were noted before the administration of the 'Concepts of Linear Measurement Test'.

All subjects had written the S.R.A. - Primary Mental Abilities Test a month prior to the investigation. This test for Grades K to 1 was designed by Thurstone in 1946 and revised in 1962. The test provides both a multifactored and a general measure of intelligence. The single-quotient score provides an estimate of intelligence similar to scores on tests such as the Stanford-Binet. The four primary mental abilities measured by the K to 1 test are: verbal meaning, number facility, perceptual speed, and spatial relations. (Thurstone, 1963)

The socio-economic status for each subject was established by referring to the Occupational Class Scale constructed by Blishen (1961). A numerical value was

then given to each subject according to the father's occupation. The data for the construction of the 'Blishen-Scale' were collected in 1951, and the ranking of occupations was based mainly on average income and average number of years of schooling. The standard scores of these two measures were combined, and each occupation was ranked according to this score. The mean for this scale is fifty and the standard deviation ten.

The ideas for the 'Concepts of Linear Measurement Test' came from Piaget (1960), Lovell (1962), and Pelletier (1966). The six subtests chosen are similar to tests used by Piaget. He used these tests to study how children judge distances and come to an understanding of conservation and measurement of length. The test was revised after a pilot study and administered again to several subjects before the actual investigation.

The test on concepts of linear measurement was chosen by the investigator because results from Smedslund (1963) and Piaget (1960) seem to indicate that the average age for the acquisition of conservation of length is about eight. Pelletier's study appears to support these findings. If bilingualism is beneficial to mental development it should be reflected in the results of the test.

A copy of the 'Concepts of Linear Measurement Test' as it was administered to the children is given in Appendix

A. A brief description of each of the six subtests is presented in the following section.

Subtest I: Reconstructing Relations of Distance

This subtest was designed to determine to what extent the concept of invariant and symmetrical linear distance is developed in the subjects. For the test two trees, A and B, were placed on a table about twenty-five inches apart. One tree (B) was standing on a three inch can. (Figure 1.)

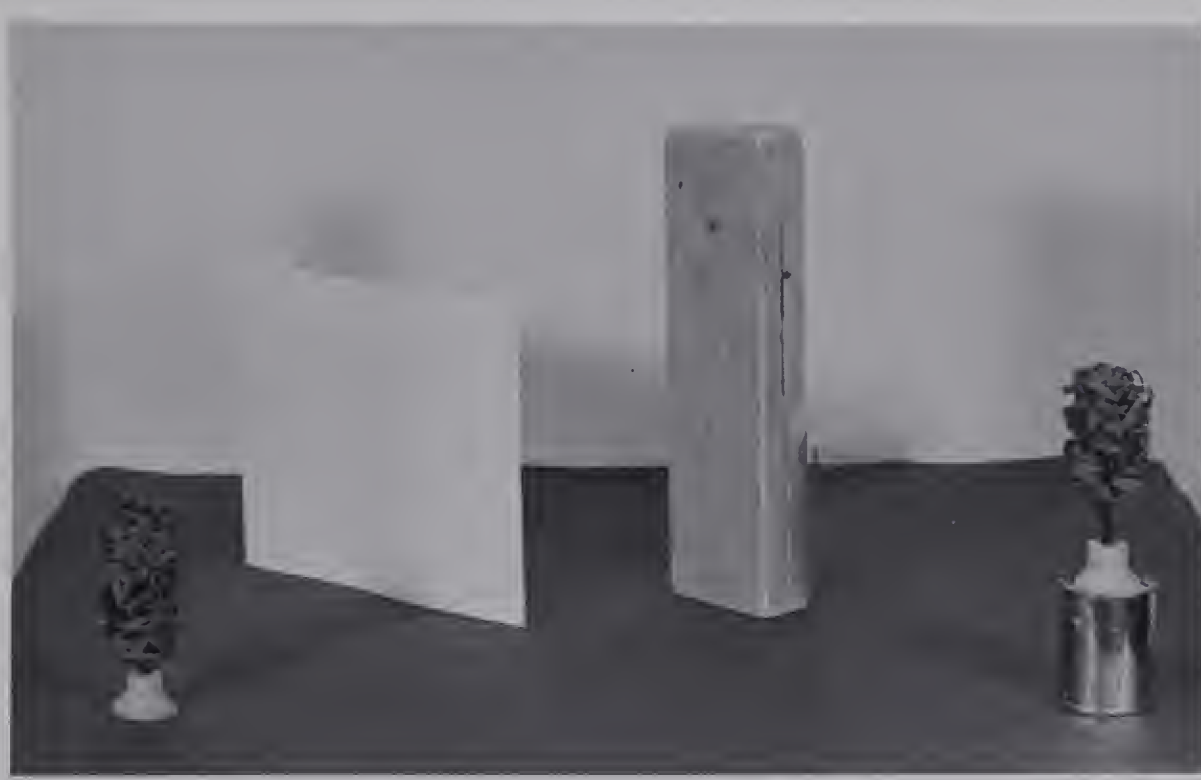

FIGURE 1

OBJECTS USED FOR SUBTEST I

(Tree on Left - A; Tree on right - B)

The children were then asked to compare the distance from A to B with the distance from B to A. This procedure was repeated by placing first a screen and later a block between the two trees. During the testing it helped a few to suggest that a bird was flying from A to B or vice versa, and have a question phrased accordingly.

Subtest II: Conservation of Length

A ten inch long stick and a piece of string fifteen inches long were used to determine the children's ability to conserve length. The subjects were faced with three arrangements and each time they were asked to state which object was longer, or if they both were the same. First the stick and string were coterminous (Figure 2), then the string was extended, and finally it was returned to its original position. The children were asked to explain how they knew one was longer than the other or how they knew they were both the same length. Their answers to this question gave some insight into how they estimated and interpreted length and whether they were conservers or thought of length only in terms of extremeties.

Subtest III: Conservation of Length with Change of Position

Before the actual questioning, all subjects agreed that the two rods were the same length. After moving the rods into the different positions (Figure 2), the subjects

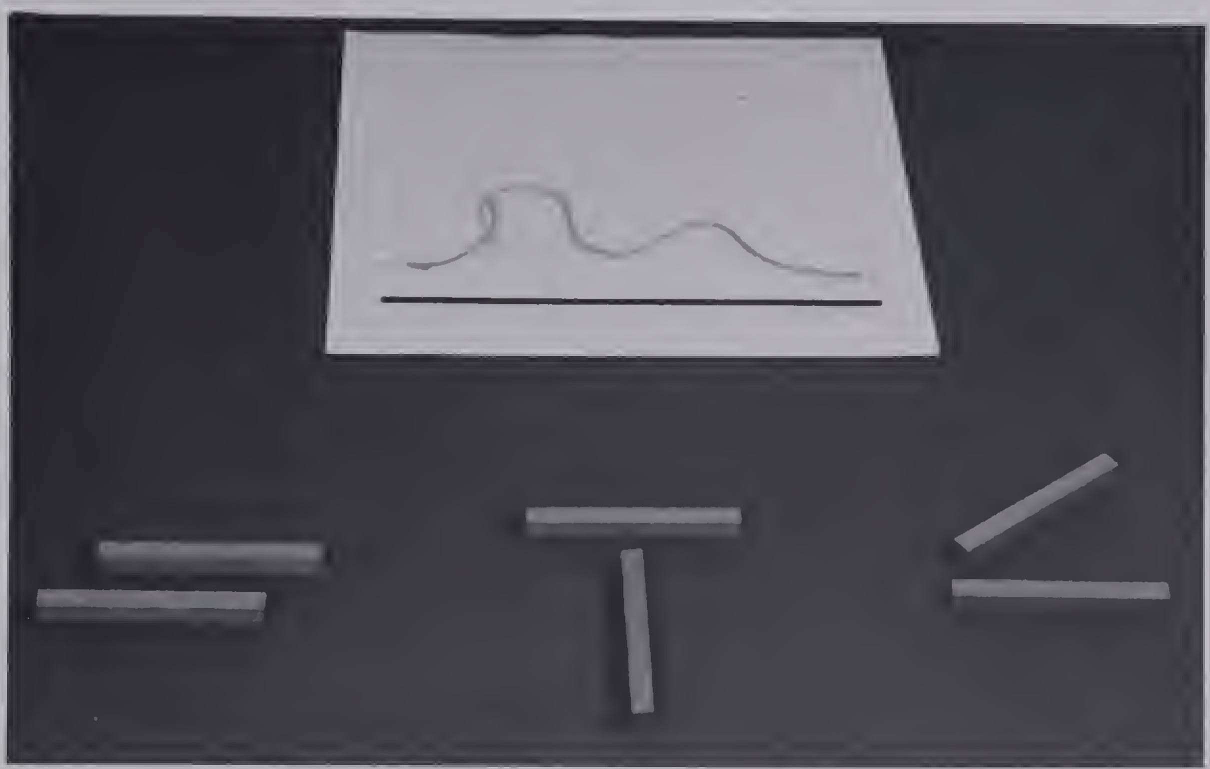

FIGURE 2

OBJECTS USED FOR SUBTEST II
POSITIONS OF CUISENAIRE RODS FOR SUBTEST III

were asked to say once again which of the two was longer or whether they were the same length. The purpose of the test was to see if children are able to consider both ends of the sticks at once and relate them to the sites which they occupy. This, of course, is a necessary condition for linking objects to reference elements.

The investigator planned on using the question "What about now?" frequently while testing the subjects. However, during the pilot study it appeared that this question asked in a certain way, made the subject change his response.

Subtest IV: Conservation of Length With Distortion of Shape

Before the questions were asked and the figures were rearranged (Figure 3), all subjects were first asked to assure themselves that the two lines of sticks and the two strips of paper were identical in length. A few times subjects disagreed, and these were asked to make them the same length.

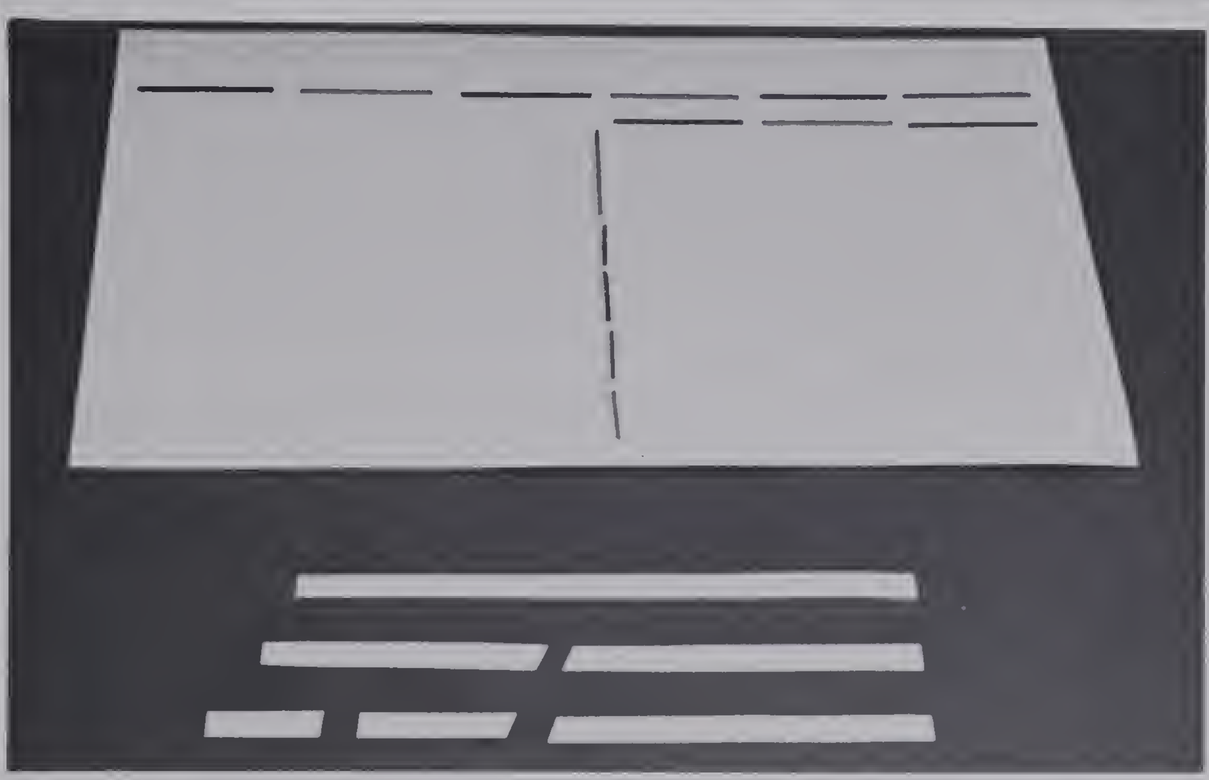

FIGURE 3

ARRANGEMENTS OF STICKS AND STRIPS
FOR SUBTEST IV

During the testing some subjects had to be reminded that we were interested in the overall distance of the sticks (or strips), and not the intervals. This was achieved by the investigator pointing to the appropriate pieces, or having the subjects pretend that an ant was walking along the sticks or pieces of the strips. The purpose of this test was to determine the child's ability to conserve length after the position of one of the objects had been modified. A correct response required that the child consider subdivision and neglect the relations between extremities.

Subtest V: Measurement of Length

The subjects were asked to judge between strips of paper in a variety of linear arrangements. (Figure 4.) These figures were pasted on cardboard. When the children had given their replies, they were asked to verify them. The question, "See if you are right." was asked. On hand were a number of movable short strips corresponding in length with the segments that were pasted on the card board. At times the investigator applied two or three short strips, explained his movements, and asked the subject to finish. Often the question, "How can you show me that you are right?" was asked after the subject had placed the short strips on the cardboard.

The purpose of this test was to determine the child's ability to measure. A correct response required operational

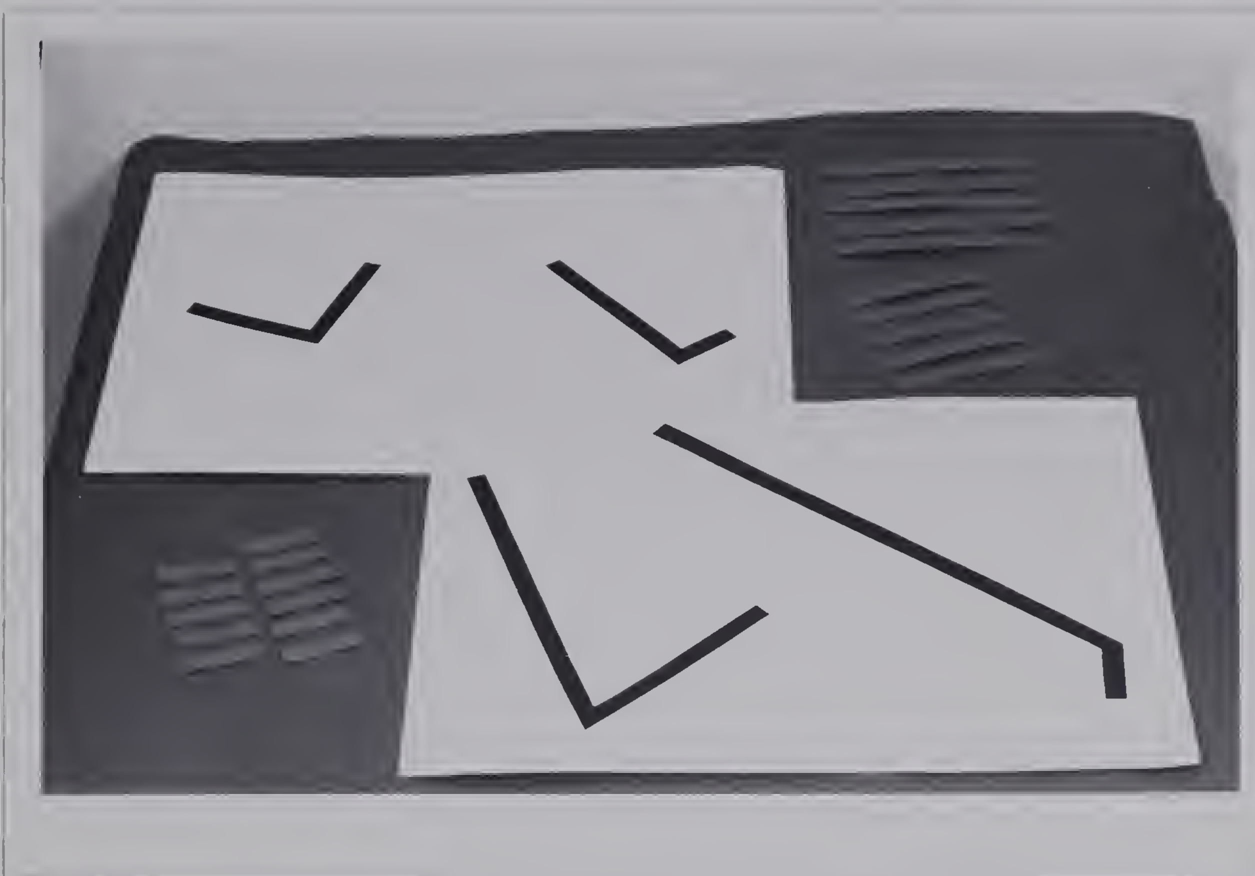

FIGURE 4

LINEAR ARRANGEMENTS AND STRIPS AVAILABLE FOR SUBTEST V

handling of measurement even though the units were not standardized.

The test showed whether the subject was capable of using the strips as an intermediary term (middle term), and equate them with first one angle and then the other. A correct response therefore, implies the possession of operational transitivity.

Subtest VI: Subdividing a Straight Line

This test was designed to determine the child's

ability to locate a segment on a straight line equal to a segment given on another straight line. Two beads on two lines (wires) were used. (Figure 5.) After the investigator moved one, he asked the subject to make the other bead travel the same length journey. All subjects participated in an introductory activity before the actual test. The beads were arranged as shown in Figure 5 so that each subject could establish his own criterion for moving his bead just as far as the investigator's. Piaget's and Pelletier's results and the pilot study indicated that very few subjects were able to measure their moves correctly since the positioning of the beads required the use of a longer stick, subdividing

FIGURE 5

OBJECTS USED FOR SUBTEST VI
ARRANGEMENTS FOR INTRODUCTORY ACTIVITY

it, and transposing it correctly. The investigator eliminated any questions that could be done correctly by visual estimation across and measurement perpendicular to the wire. All questions required some measurement or estimating in the direction along the wire.

III. TESTING, SCORING AND STATISTICAL PROCEDURES

The testing was done in the schools during the month of May, 1968. Each subject was tested individually by the investigator in a room set aside by the principal (library, nurse's room, spare classroom). Only the child and the investigator were present, and the answers were recorded on the score sheet (Appendix B) as the child gave them. Comments were added as the child returned to his classroom and the teacher sent the next pupil.

The apparatus and equipment for the subtests was arranged in six stations on two tables. The investigator and subject walked along the table, beginning with subtest one. For subtest five and six, chairs were available for the investigator and subject. The average testing time was about fifteen minutes.

The actual scoring was done by assigning a one for the correct response and a zero for an incorrect one. Thus there existed a possibility of eighteen marks for the whole test. For subtest five a one was given if the subject measured correctly, and for subtest six if he

subdivided the straight line correctly. Whether a one was given for the last test, depended on the visual estimate by the investigator ($\pm$ 1/2 inch). Usual and unusual explanations to the question, "How do you know?" were recorded but not scored.

All the data were analyzed by a computer using programs supplied by the Division of Educational Research of the Faculty of Education, University of Alberta. Each student was assigned an identification number. Since the study controlled for age, intelligence, socio-economic status, sex and kindergarten attendance, the hypotheses were tested by using the Multiple Linear Regression Model (Hunka, 1966) and the REG - 200 computer program. The resultant F-ratios were analyzed at the .05 level of significance. The $\underline{t}$-ratios were calculated with the aid of a computer program for IBM/67 that uses Iverson's A.P.L. notation. The 'Concepts of Linear Measurement Test' was scored by the investigator and the results were analyzed using the Test Scorer and Item Analysis or TESAN - 100 computer program.

CHAPTER IV

THE RESULTS OF THE STUDY

In this chapter the results of the study are summarized and analyzed. The discussion will be presented in the following order. The nature of the two samples is described. Then the results of the 'Concepts of Linear Measurement Test' are presented and analyzed. The more significant responses to the subtests are noted and discussed. Finally, a summary of the findings is presented.

I. THE NATURE OF THE SAMPLES

To get the two samples required for this study a request for assistance was made to the Edmonton Separate School System. The Supervisor for Elementary Education provided the names of six schools. The principals from these schools made nine grade one classrooms available. Three of the classrooms contained bilingual children who received instruction in both English and French. The monolingual children were chosen from the remaining six classrooms. Instruction in these rooms was carried out solely in English.

The criterion for choosing the monolingual subjects was that they had no functional knowledge of a second language, and that only one language was spoken at home. One-hundred-thirty-seven pupils in these classrooms met

this criterion. A table of random numbers was used to select a sample of fifty subjects. There were twenty-five girls and twenty-five boys in the monolingual sample.

Bilinguals were defined as children who had used English and French before entering school and who were exposed to both languages at home. The teachers of the three classrooms helped in choosing fifty subjects who satisfied the condition of bilingualism. The bilingual sample consisted of twenty-five girls and twenty-five boys.

Although the programs varied somewhat for the three classrooms, the bilingual subjects used both languages in school. Before Christmas the three and one-half hours of instructional time in grade one was divided into one hour of instruction in English and the remainder in French. When the data for this study were collected, the time allotted for instruction in each language was about the same. Most of the casual conversation between the teacher and the student was carried out in French.

The main purpose of this study was to investigate the effects of bilingualism on the development of certain concepts. Information on other factors that could affect concept development was gathered. These data included information on age, socio-economic status, intelligence, and kindergarten attendance. The data on these variables were used to check for any significant differences between

the two samples. The data analysis program used to compare the differences in means for the two samples on the 'Concepts of Linear Measurement Test' controlled for all the variables listed above.

The age for all the subjects was calculated on the day the test on concepts of linear measurement was administered. It was computed to the nearest month. Distribution for the two samples and the total group, means, variances and standard deviations are shown in Table III. A *t*-test was used in comparing the means of the monolingual and bilingual group. The differences in means was not significant.

To compare the socio-economic status of the two samples, the Blishen Occupational Class Scale (1961) was used. On this scale occupations are equated with a numerical value. The appropriate index value was assigned to each subject on the basis of the father's occupation. For four cases, the mother's occupation had to be used. The index value ranged from 75.0 to 41.6 for the monolingual sample, and from 78.8 to 43.2 for the bilingual sample. The distribution, means, variances, and standard deviations of the Blishen Occupational Class Scale scores for both samples and the total group are shown in Table IV. A *t*-test was used to compare the means of the monolingual and bilingual group. This difference in means was not significant.

TABLE III

DISTRIBUTION, MEANS, VARIANCES AND STANDARD DEVIATIONS OF AGES FOR MONOLINGUALS, BILINGUALS AND TOTAL GROUP

Age (years)	Monolingual	Bilingual	Total
8.25	1	0	1
8.08	1	0	1
7.42	0	1	1
7.33	3	2	5
7.25	3	3	6
7.17	4	3	7
7.08	2	4	6
7.00	2	6	8
6.92	5	6	11
6.83	5	4	9
6.75	5	2	7
6.67	4	4	8
6.58	5	3	8
6.50	1	3	4
6.42	3	3	6
6.33	4	2	6
6.25	2	3	5
6.17	0	1	1
Mean	6.85*	6.82*	6.83
Variance	0.17	0.10	0.14
Standard Deviation	0.41	0.32	0.37

* Means compared: $\underline{t}$ (calculated) = 0.435
$\underline{t}$ (.05) = 1.985

TABLE IV

DISTRIBUTION, MEANS, VARIANCES, AND STANDARD DEVIATIONS OF BLISHEN OCCUPATIONAL CLASS SCALE SCORES FOR MONOLINGUALS, BILINGUALS, AND TOTAL GROUP

	Monolinguals	Bilinguals	Total
76 - 80	0	1	1
71 - 75	1	1	2
66 - 70	1	0	1
61 - 65	3	2	5
56 - 60	2	3	5
51 - 55	6	6	12
46 - 50	18	20	38
41 - 45	19	17	36
Mean	49.16*	49.56*	49.36
Variance	54.58	52.26	52.56
Standard Deviation	7.39	7.23	7.25

* Means compared: $\underline{t}$ (calculated) = 0.265
$\underline{t}$ (.05) = 1.985

During the month of April, 1968 the classroom teachers administered the S.R.A. - Primary Mental Abilities Test. (Thurstone, revised 1962 - Grades K to 1) to all pupils. The scores used in this study were taken from a list provided by the principals and recorded by the teachers. For the monolingual sample the intelligence quotients ranged from 135 to 86, and for the bilingual sample from 128 to 75. The intelligence quotient distribution, means,

variances, and standard deviations for both samples and the total group are shown in Table V. A *t*-test was used in comparing the means of the monolingual and bilingual group. The difference in means was not significant.

TABLE V

DISTRIBUTION, MEANS, VARIANCES, AND STANDARD DEVIATIONS OF S.R.A. - PRIMARY MENTAL ABILITIES TEST SCORES FOR MONOLINGUALS, BILINGUALS, AND TOTAL GROUP

	Monolinguals	Bilinguals	Total
131 - 135	2	0	2
126 - 130	1	2	3
121 - 125	4	3	7
116 - 120	4	7	11
111 - 115	8	2	10
106 - 110	8	6	14
101 - 105	9	11	20
96 - 100	7	9	16
91 - 95	3	5	8
86 - 90	4	3	7
81 - 85	0	0	0
75 - 80	0	2	2
Mean	107.40*	104.22*	105.81
Variance	138.90	150.62	144.48
Standard Deviation	11.79	12.27	12.02

* Means compared: *t* (calculated) = 1.325
t (.05) = 1.985

Before the administration of the test on concepts of linear measurement a check was made on each subject's pre-school experience. Fifty-two per cent of the monolingual sample and seventy-four per cent of the bilingual sample had attended either kindergarten or playschool. Since the difference in attendance for the two samples is rather large, the significance of kindergarten attendance in predicting scores on 'Concepts of Linear Measurement Test' was checked. Independent of group membership, the kindergarten attendance and the scores on the test were correlated. The resultant correlation coefficient (Pearson Product-Moment) of 0.141 was not significant.

II. TEST RESULTS: SUMMARY AND STATISTICAL ANALYSIS

In this section the results of the 'Concepts of Linear Measurement Test' are presented and analyzed. The test consisted of two parts. Part one included subtests one to four and was designed to determine the child's ability to conserve length. The two subtests of part two were designed to determine the child's ability to subdivide a straight line and measure with a non-standard unit. Each subject was tested individually and the scoring was done by assigning a one for the correct response and a zero for an incorrect one. The answers were recorded as each subject replied.

The Kuder-Richardson 20 formula was used to determine the internal consistency of the test on concepts of linear measurement. This formula gives an indication of the extent to which each item measures what the whole test measures. The KR-20 reliability coefficient for the test was .7855.

The test consisted of eighteen items. Since the responses to each item were scored as either right or wrong, a genuine dichotomy existed, and the point-biserial correlation coefficient could be calculated. The point-biserial correlation coefficient and difficulty index for each item are shown in Table VI.

The number of correct responses for both samples ranged from four to eighteen. Six bilingual and three monolingual subjects obtained a perfect score. Thirteen bilingual and three monolingual subjects scored seventeen out of eighteen on the test. The frequency distribution of correct responses for both samples is shown in Figure 6.

To compare the two samples, the means, variances and standard deviations for the total test were obtained. The results are summarized in Table VII. For the total test there existed a difference in means of 3.00 between the two samples. The means for the two parts on the test also differed. For part one the mean score for the monolingual subjects was 7.02, and for the bilingual subjects 9.20. The overall mean for this part was 8.12.

TABLE VI

RESULTS OF THE TEST ITEM ANALYSIS

Item Number	Point-Biserial Correlation	Difficulty Index* (N=100)
1	.255	.770
2	.536	.710
3	.573	.710
4	.519	.770
5	.000	1.000
6	.710	.630
7	.823	.490
8	.789	.650
9	.969	.620
10	.831	.480
11	.673	.650
12	.663	.630
13	.813	.530
14	.764	.400
15	.744	.820
16	.596	.940
17	.652	.660
18	.492	.750

* A difficulty index of .770 means that 77 subjects had a correct response and 23 had an incorrect response.

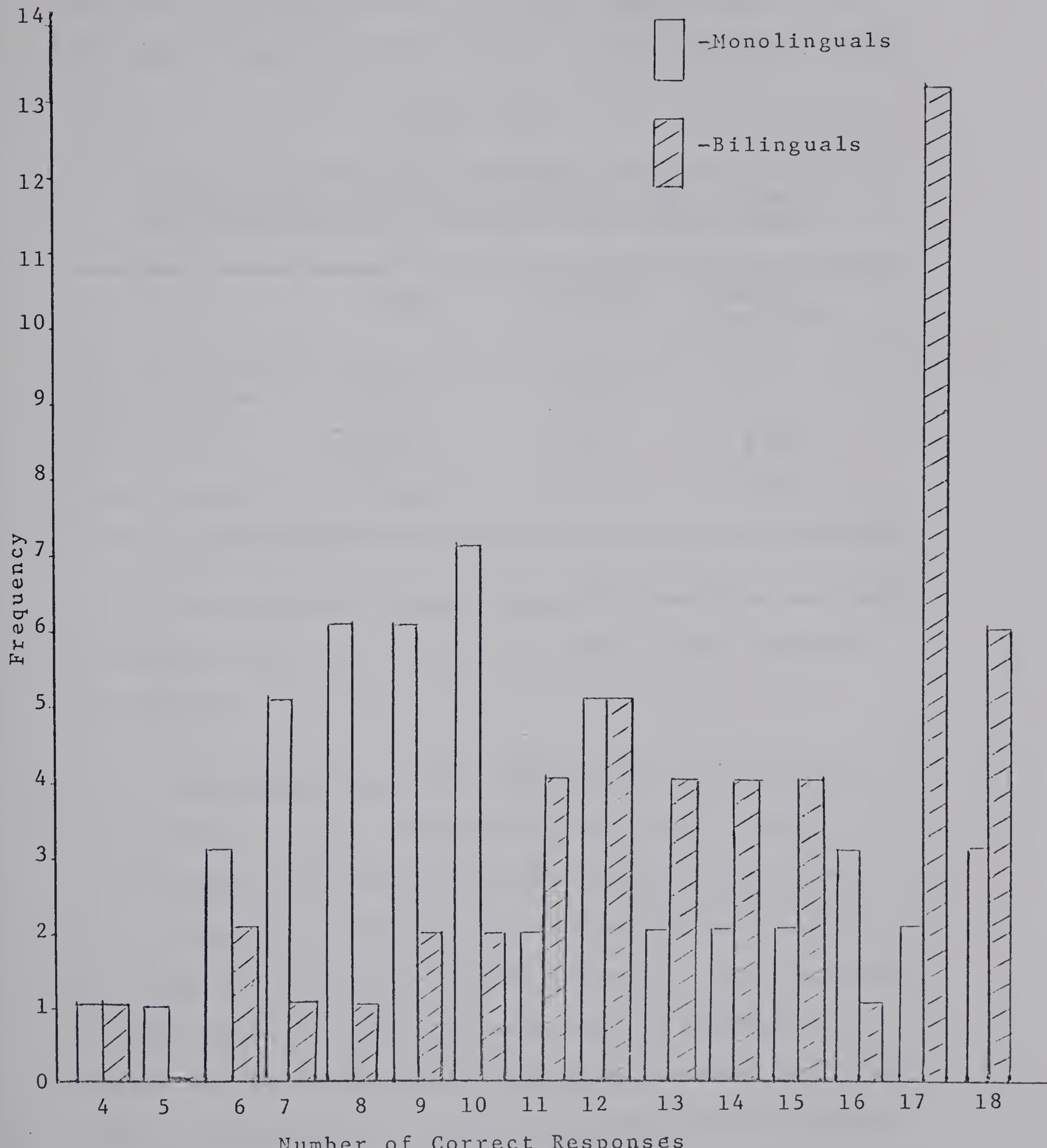

FIGURE 6

FREQUENCY DISTRIBUTION OF CORRECT RESPONSES FOR BOTH SAMPLES ON 'CONCEPTS OF LINEAR MEASUREMENT TEST'

For part two the mean for the monolinguals was 3.68, for the bilinguals 4.52, and the overall mean was 4.10.

TABLE VII

MEANS, VARIANCES AND STANDARD DEVIATIONS OF 'CONCEPTS OF LINEAR MEASUREMENT TEST' SCORES FOR MONOLINGUALS, BILINGUALS AND TOTAL GROUP

	Mean	Variance	Standard Deviation
Monolinguals	10.72	13.88	3.72
Bilinguals	13.72	13.72	3.70
Total Group	12.22	15.76	3.97

The multiple-linear regression analysis was used to analyze the test results in terms of the research hypotheses.

Hypothesis 1: When adjustments are made for differences in age, kindergarten attendance, sex, intelligence, and socio-economic status, monolingual and bilingual children do not differ in their understanding of linear measurement concepts. The analysis results indicated that the mean for the bilingual sample on the 'Concepts of Linear Measurement Test' was significantly higher than the mean for the monolingual sample. Consequently this hypothesis was rejected. The results of the analysis are shown in Table VIII.

<u>Hypothesis 2</u>: When adjustments are made for differences in age, kindergarten attendance, sex, intelligence, and socio-economic status, monolingual and bilingual children do not differ in their ability to conserve length. The results of the analysis revealed that the mean for the bilingual sample on the conservation part of the test (subtests one to four) was significantly higher than the mean for the monolingual sample. Therefore, this hypothesis was rejected. The results are shown in Table VIII.

<u>Hypothesis 3</u>: When adjustments are made for differences in age, kindergarten attendance, sex, intelligence, and socio-economic status, monolingual and bilingual children do not differ in their ability to measure length. In testing this hypothesis the results of the analysis indicated that the mean for the bilingual sample on the measurement part of the test (subtests five and six) was significantly higher than the mean for the monolingual sample. As a result the hypothesis was rejected. The results of the analysis are shown in Table VIII.

TABLE VIII

MULTIPLE-LINEAR REGRESSION ANALYSIS RESULTS FOR HYPOTHESES ONE TO THREE

Source	Degrees of Freedom		F-Ratio
	Num.	Den.	
Total Test	1	94	16.04*
Part 1 (Conservation)	1	94	8.41*
Part 2 (Measurement)	1	94	18.08*

* $F_{.05}$ (1,94) = 3.95

From the available data, the following secondary hypotheses were also tested. The multiple-linear regression analysis was used and the monolingual and bilingual subjects were treated as one sample.

Hypothesis 4: Age is not a factor in predicting a child's ability to understand the concepts of linear measurement. The test of this hypothesis produced an F-ratio that was not significant. As a result this hypothesis was not rejected. The result of the analysis is shown in Table IX.

Hypothesis 5: Kindergarten attendance is not a factor in predicting a child's ability to understand the concepts of linear measurement. The F-ratio obtained from the test of this hypothesis was not significant. Therefore this hypothesis was not rejected. The results

of the test are shown in Table IX.

Hypothesis 6: Sex is not a factor in predicting a child's ability to understand the concepts of linear measurement. The resultant F-ratio was not significant. Consequently this hypothesis was not rejected. In Table IX the results of the test are shown.

Hypothesis 7: Intelligence is not a factor in predicting a child's ability to understand the concepts of linear measurement. Subjects with a high I.Q. scored higher on the test. The resultant F-ratio of 4.164 was significant. Therefore, this hypothesis was rejected. The result of this analysis is shown in Table IX.

TABLE IX

RESULTS OF THE ANALYSES FOR HYPOTHESES FOUR TO EIGHT

Source	Degrees of Freedom		F-Ratio
	Num.	Den.	
Age	1	99	0.73
Kindergarten Attendance	1	99	2.02
Sex	1	99	2.87
Intelligence	1	99	4.16*
Socio-economic Status	1	99	3.85

* $F_{.05}$ (1,99) = 3.94

Hypothesis 8: Socio-economic status is not a factor in predicting a child's ability to understand the concepts of linear measurement. The F-ratio obtained from the test of this hypothesis was not significant. Consequently this hypothesis was not rejected.

III. RESPONSES TO SUBTESTS

The 'Concepts of Linear Measurement Test' consisted of two parts. Part one dealt mainly with conservation of length and it included subtests one to four. Part two dealt with measurement of length and was made up of subtests five and six. Subtest one dealt with reconstructing relations of distance. Subtests two, three, and four dealt with conservation of length, conservation of length with change of position, and conservation of length with distortion of shape respectively. Subtest five was devised to check on the ability to measure length, and subtest six was designed to measure the subject's ability to subdivide a straight line. The order of succession was the same for each subject and proceeded from subtest one to subtest six. The arrangements for the subtests were similar for all the subjects, and the questions asked varied little.

In Table X the parts of the test, the number of subtest for each part, and the number of questions in each subtest are shown. Also shown are the number of correct responses for the monolingual and bilingual subjects to

TABLE X

NUMBER OF CORRECT RESPONSES FOR BOTH SAMPLES ON THE 'CONCEPTS OF LINEAR MEASUREMENT TEST'

Parts of Tests	Sub-tests	Question Number	Monolinguals (N=50)	Bilinguals (N=50)
1. "Conservation of Length"	I	1	35	42
		2	32	39
		3	32	39
	II	4	35	42
		5	50	50
		6	23	40
	III	7	21	28
		8	28	37
		9	24	38
	IV	10	20	28
		11	24	41
		12	27	36
2. "Measurement"	V	13	20	33
		14	15	25
	VI	15	39	43
		16	45	49
		17	28	38
		18	37	38

each of the questions.

Subtest I: Reconstructing Relations of Distance

This test was designed to inquire into the child's understanding of distance. Distances here, refers to the linear separation of two objects, or the empty space between them.

The test consisted of three main questions. First the child was asked whether it was farther from one tree to another situated on a four inch can twenty five inches away, vice versa, or whether the distance was the same either way. Some of the subjects who responded incorrectly suggested that it was so because one tree was taller, or because one was on the can. Even movement of the finger parallel to the table, from one tree to the other and back, was not enough evidence to convince them otherwise.

Before proceeding with questions two and three, each child was asked if the two trees were "near one another" or "far apart". The majority of the subjects, forty-four monolinguals and forty-five bilinguals judged the trees to be far apart.

After the child had decided whether the two trees were near or far apart, a screen was placed between the trees. The child was then asked, "Are the trees closer together now, farther apart, or are they the same as they were before?" The screen was removed, a block was placed between the trees, and the same question was asked.

To forty-two of the subjects the introduction of the screen or block did not make any difference. They judged the distance between the trees to be the same as before. However, thirty-six monolingual and twenty-two bilingual subjects thought that the screen or block brought the trees closer together or made them farther apart.

Answers to the question "Why?", and "How do you know?" required the subjects to give reasons for their responses. Some of the children who thought that the trees were closer after introducing the objects concentrated only on the distance from one tree to the object and neglected the overall distance all together. Others, when the block was involved, pointed to its width and stated that the distance was "that much less". The children who thought the distance between the trees to be farther, interpreted 'distance' as going over or around the introduced obstacles.

The highest possible score for Subtest I was three. Thirty bilingual and nineteen monolingual subjects achieved a perfect score on this test. In Table XI the distribution of scores for Subtest I is shown.

TABLE XI

SUMMARY OF SCORES FOR SUBTEST I: NUMBER OF SUBJECTS ACHIEVING SCORE

Score	Monolinguals	Bilinguals	Total
3	19	30	49
2	14	11	25
1	14	8	22
0	3	1	4

Subtest II: Conservation of Length

The three questions of this subtest were designed to determine if children were beyond the stage of interpreting 'length' in terms of the two endpoints only. All three parts of the subtest involved repeating the same question, "Which is longer, the stick, the string, or are they the same?". While the question was asked, the curves made by the objects were traced.

For question four, the endpoints of the string and stick were coterminous (Figure 2 - Chapter 3). For question five the string was extended and all subjects answered the question correctly. Although it was marked along with the other responses, this question was to serve as a preparatory activity for question six. For question six, the endpoints of the objects were again coterminous. Interestingly enough, there were fewer correct responses for question six than for question four. The number of correct replies decreased by twelve for the

monolingual and by two for the bilingual children. It was felt that the subjects who were not conservers, after being asked the same question three times, thought the answer should be different.

Non-conservers supplied a variety of responses to the question, "How do you know?". Some of the subjects just shrugged their shoulders and moved their eyes closer to the table for a horizontal inspection. One boy kept insisting that the stick was longer, but he refused to give any reasons. Twenty-two monolinguals and forty bilinguals answered all three questions correctly. A summary of the scores is shown in Table XII.

TABLE XII

SUMMARY OF SCORES FOR SUBTEST II: NUMBER OF SUBJECTS ACHIEVING SCORE

Scores	Monolinguals	Bilinguals	Total
3	22	40	62
2	14	2	16
1	14	8	22

Subtest III: Conservation of Length with Change of Position

Two sticks of equal length were used for this test. The position of one was changed three times (Figure 2 - Chapter 3) to determine whether children could conserve length, or if they thought of length in terms of the most distant points only.

Before the questions were asked all subjects agreed that the two sticks were the same length. Two subjects did so only after standing the sticks on end and carefully inspecting them. Seventeen monolingual and twenty-five bilingual subjects answered all three questions correctly. A summary of the scores is shown in Table XIII.

TABLE XIII

SUMMARY OF SCORES FOR SUBTEST III: NUMBER OF SUBJECTS ACHIEVING SCORE

Scores	Monolinguals	Bilinguals	Total
3	17	25	42
2	6	10	16
1	10	8	18
0	17	7	24

A rather interesting observation was that some subjects from both samples who answered question seven of the subtest incorrectly, gave the correct reply for questions eight and nine. It could be that for partial conservers the interpretation of length in terms of the endpoints for question seven was too obvious. Whereas for questions eight and nine some conflict was produced and the subjects realized that length should not be interpreted in that manner. For these subjects question seven was repeated after they had answered eight and nine

correctly. However, all of them persisted in repeating the same incorrect answer. It could have been that they avoided contradicting themselves.

Non-conservers, in giving their reasons for one stick being longer, explained that one end was sticking out, or that one stick pointed in a certain direction. For the subjects from both samples who answered questions eight and nine incorrectly, the choice between the sticks was about equally divided. However, for question seven, nineteen out of twenty-nine monolinguals, and fourteen out of twenty-two bilinguals chose the stick nearer themselves.

Subtest IV: Conservation of Length with Distortion of Shape

This subtest consisted of two parts. In both parts an attempt was made to determine the child's ability to conserve length after one of the objects had been modified and its position had been changed.

For the test the subjects were faced with two parallel lines consisting of six counting sticks each, and two strips of paper of equal length. Before the actual testing all of the children agreed that the lines and strips were of the same length. One boy cut an equal piece off each of the strips before he was satisfied that they were the same length.

For question ten, one of the lines of sticks was re-arranged to form a right angle, and two of the sticks

were broken. For questions eleven and twelve, one of the strips was cut once and twice respectively. (Figure 3 - Chapter 3). The subjects were then asked to decide whether the lines of sticks and the strips were still the same length, or if one of the two was longer. Fifteen monolingual and twenty-six bilingual subjects answered the three questions correctly. The scores for Subtest IV are summarized in Table XIV.

TABLE XIV

SUMMARY OF SCORES FOR SUBTEST IV: NUMBER OF SUBJECTS ACHIEVING SCORE

Score	Monolinguals	Bilinguals	Total
3	15	26	41
2	8	12	20
1	10	3	13
0	17	9	26

During the testing some subjects had to be reminded that the sticks and pieces of the strips were to be considered, and not the intervals. However, many subjects were not able to ignore the intervals between the sticks and between the strips. The reasons for their answers were quite revealing and different. For the sticks some subjects chose the top line to be longer because "it was straight", others the bottom line because "it went around a corner". The subjects who chose the modified part of the line of

sticks, usually attempted to set up a one-to-one correspondence between the pieces, even though their lengths differed. For the strips most non-conservers chose the top piece since it was not cut. A few subjects claimed that "two pieces must be longer than one" and they chose the cut pieces.

For all questions, and for both samples, the majority of choices belonged to the unmodified or top part. Many of the children at this age interpreted length in terms of the endpoints only. That could be the reason for selecting the straight line of sticks. However, this reasoning appears to disappear and be reversed for question eleven and twelve. Here the majority of non-conservers chose the uncut strip which in terms of the endpoints appears "shorter". The choices made by the subjects who answered questions ten to twelve incorrectly are shown in Table XV.

TABLE XV

ANALYSIS OF INCORRECT RESPONSES FOR SUBTEST IV:
NUMBER OF SUBJECTS CHOOSING EACH ALTERNATIVE

Group	Choice	Questions		
		10	11	12
Monolinguals	Unmodified (top)	21	21	13
	Modified (bottom)	9	5	10
Bilinguals	Unmodified (top)	18	6	11
	Modified (bottom)	4	3	3

Many subjects who responded incorrectly to question ten gave the correct answer for questions eleven and twelve. It could be that for some of the children there were too many variables to be considered for question ten: a greater number of intervals, a change in direction, and two of the sticks being broken.

Subtest V: Measurement of Length

This subtest was used to check on the child's ability to measure with an unfamiliar unit. A correct response required the use of subdivision, accurate placement of the 'units', and matching or change of position. The latter requirement involved conservation, or knowing that movement does not change length.

The subjects were asked to judge between strips of paper in a variety of linear arrangements (Figure 4 - Chapter 3). These figures were pasted on cardboard. When the subjects had given their replies, they were shown a number of movable strips, and asked to verify their judgement.

During the pilot study which was carried out in December, 1967 all subjects in giving their estimation stated that the linear arrangement with the longest segment looked to be longer. However, children in this study gave all three choices. Although most of the subjects estimated the arrangement with the longest segment to be longer, there were others who chose the alternate figure. Some children stated that both arrangements might be the same length. Only

one, a monolingual child, stated that he could not tell. He proceeded to measure and compare the two arrangements correctly.

After the perceptual estimation, each subject was asked the following question: "Could you use any of these short strips to show me that you are right?" For the first question of the subtest, the experimentor at times applied one or two of the short strips, explained his movements, and asked the subject to complete the task. Often, after the subject had succeeded in putting strips along the figures, he was asked the question: "Could you show me now that your guess was right?". Fifteen monolingual and twenty-one bilingual subjects were able to measure correctly. The scores for Subtest V are summarized in Table XVI.

TABLE XVI

SUMMARY OF SCORES FOR SUBTEST V: NUMBER OF SUBJECTS ACHIEVING SCORE

Scores	Monolinguals	Bilinguals	Total
2	15	21	36
1	5	16	21
0	30	13	43

Some interesting observations were made during the administration of this subtest. Many subjects who were unable to measure provided rather unique proofs for their

estimation. A few put all the short strips end to end. Others extended the figures by annexing the strips onto their ends. Still others put strips on only one of the figures. All of them were convinced that theirs constituted a legitimate proof for the estimate they had given.

Two subjects, who had estimated the linear arrangement with the longest segment to be longer, proceeded to measure correctly, but did not want to change their minds. A few subjects who estimated one figure to be longer, and found them to be the same length, changed their estimate for the next question by saying that "both might be the same".

As mentioned previously, for question thirteen, the examiner at times applied one or two strips to clarify the task for the subjects. Many subjects from both samples who completed question thirteen correctly, could not apply the same procedure to the larger figures of question fourteen. Both samples obtained the lowest scores of the test for question fourteen.

Subtest VI: Subdividing a Straight Line

The four questions on this test were designed to determine how well children can locate a segment on a straight line equal to a segment given on another straight line. An introductory activity was used to familiarize the subjects with the task.

After the experimentor had moved his bead and the subjects had responded, they were asked to show or prove that they had moved their bead the same distance along the wire. Three sticks of different lengths were available to them (Figure 5 - Chapter 3).

The questions were designed in such a way that none of them could be answered correctly by measuring straight across and perpendicular to the wires. Also, the positioning of the beads required the use of a longer stick and subdividing it.

Most subjects were unable to use the sticks, and they were asked to show that their answer was correct in any other way they could. A subject received full marks if he moved his bead approximately the same distance as the experimentor had moved his. There were a great variety of methods for measuring. The methods used for question fifteen and sixteen were classified, and the results are shown in Table XVII.

TABLE XVII

ANALYSIS OF RESPONSES FOR SUBTEST VI: METHOD OF MEASUREMENT USED BY SUBJECTS FOR QUESTIONS FIFTEEN AND SIXTEEN

Method	Monolinguals	Bilinguals
Correct Procedure	3	6
Diagonally Across	12	3
Visual Comparison	17	15
Use of Shorter Stick	16	17
Manual Transfer	2	4
Body Transfer	0	5

The test in itself was a learning situation. Many subjects changed their methods from question to question. One subject used a different method for each question. He measured diagonally across, used manual transfer, measured from the opposite ends, and finally used one of the sticks correctly.

Most subjects complained that the sticks were not the right size. They stated that they could measure correctly if they had another small stick, or if they were allowed to break one of the longer ones. As a response to the question, "Could you show me any other way?", six subjects proved the correctness of their response by moving the frames together, picking one up and turning it around whenever necessary. Five children used finger spans or finger widths. Many of the subjects who used the shorter stick, measured the remainder by using their fingers.

The responses for question sixteen represent the highest score for both groups on the test. For this question the distance was easily estimated. The number of correct responses for question seventeen decreased considerably. Many subjects responded by simply moving their bead until it was beside the experimentor's bead. Twenty-four monolingual and thirty-four bilingual subjects responded correctly to all four questions. A summary of the scores for Subtest VI are shown in Table XVIII.

TABLE XVIII

SUMMARY OF SCORES FOR SUBTEST VI: NUMBER OF SUBJECTS ACHIEVING SCORE

Scores	Monolinguals	Bilinguals	Total
4	24	34	58
3	9	8	17
2	11	1	12
1	4	6	10
0	2	1	3

IV. SUMMARY OF THE RESULTS

The results of the data analysis may be summarized as follows:

I. In terms of the two samples:

There existed no significant difference between the monolingual and the bilingual samples on the basis of age, socio-economic status and intelligence.

II. For the major research hypotheses:

When adjustments were made for differences in age, kindergarten attendance, sex, intelligence, and socio-economic status:

(1) the mean for the bilingual children on the 'Concepts of Linear Measurement Test' was significantly higher than the mean for the monolinguals.

(2) the mean for the bilingual subjects on the test of 'Conservation of Length' (Subtests I to IV) was significantly higher than the mean for the monolingual

children.

(3) the mean for the bilinguals on the test of 'Measurement of Length' (Subtests V and VI) was significantly higher than the mean for the monolingual children.

III. For the secondary hypotheses:

(1) Age, kindergarten attendance, sex, and socio-economic status were not significant factors in predicting scores on the 'Concepts of Linear Measurement Test'.

(2) Intelligence was a significant factor in predicting scores on the 'Concepts of Linear Measurement Test'. It was found that the higher the I.Q., the more advanced the development of the concepts of linear measurement as measured by this test.

IV. For the subtests:

(1) On none of the subtests did the monolinguals score higher than the bilingual subjects.

(2) The greatest difference in correct responses for the two samples was for subtest two, 'Conservation of Length'. Forty bilingual and twenty-two monolingual subjects replied correctly to all three questions.

(3) The least difference in correct responses for the two samples was for subtest five 'Measurement of Length'. Twenty-one bilingual and fifteen monolingual subjects responded correctly to the two tasks.

(4) On none of the questions did the monolinguals

score higher than the bilingual subjects.

(5) The greatest and least number of correct responses for both samples were for questions sixteen and fourteen, respectively.

(6) The number of correct responses ranged from four to eighteen for both samples.

(7) Six bilinguals and three monolingual subjects obtained a perfect score.

(8) Thirteen bilingual and three monolingual subjects obtained a score of seventeen out of a possible eighteen on the test.

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

I. SUMMARY OF THE STUDY

It was the purpose of this study to attempt to isolate one experience and test for its effects on mental development. The assumption was made that learning two languages at an early age is a unique experience. The child who becomes bilingual is involved in an enriched environment as a result of a special kind of social interaction. A comparison of certain aspects of concept development of bilingual children and monolingual children was made. To make this comparison, a test on concepts of linear measurement was constructed to serve as the main instrument. The test consisted of six subtests and they dealt with the following aspects of linear measurement:

(1) reconstructing relations of distance,

(2) conservation of length,

(3) conservation of length with a change of position,

(4) conservation of length with distortion of shape,

(5) measurement of length, and

(6) subdividing a straight line.

Each of these subtests is similar to the tests devised by Jean Piaget (1960). He used them to find out how children judge distances and how they come to an under-

standing of conservation and measurement of length.

A sample of bilingual children and a similar sample of monolingual children were selected for the study. Officials of the Edmonton Separate School System suggested the names of six schools. The principals of these schools made nine grade one classrooms available. Fifty monolingual children were randomly selected from six of these rooms. The classroom teachers helped in selecting the fifty subjects for the second sample from the remaining three rooms which were set up for bilingual children. The bilinguals received instruction in English and French, whereas the monolinguals were instructed solely in English. There were twenty-five females and twenty-five males in each of the samples.

The 'Concepts of Linear Measurement Test' was administered individually to each subject by the investigator during the month of May, 1968. Additional data collected about each child included I.Q., birth date, father's occupation, kindergarten attendance and sex.

The tests were scored and each of the subtests was analyzed. To find out whether the two samples differed significantly on the basis of age, socio-economic status, and intelligence, *t*-ratios were calculated. Multiple linear regression analysis was used to determine whether the means on the 'Concepts of Linear Measurement Test' differed significantly for the monolingual and bilingual sample. The same statistical analysis was used to find

out if any one of the factors: age, kindergarten attendance, sex, intelligence, and socio-economic status is a significant factor in predicting scores on a test of concepts of linear measurement.

II. CONCLUSIONS

The *t*-test results showed that with respect to age, socio-economic status, and intelligence the differences between the monolingual and the bilingual sample were not significant. On the basis of testing the research hypotheses the following conclusions may be drawn:

(1) The mean for the bilingual sample on the 'Concepts of Linear Measurement Test' was significantly higher than the mean for the monolingual sample. This result is in agreement with Peal and Lambert's (1962) finding that bilingualism has favorable effects on intellectual functioning. From their study they concluded that bilinguals were more facile at concept formation.

Guilford (1956, 1959) discovered fifty different factors of intelligence. He states that the emergence of any one intelligence factor is dependent on the accumulation of experience. The results of this study seem to indicate that the linguistic and cultural experience of the bilinguals is an advantage. The intelligence factors necessary for concept formation seem to be developed to a greater extent in the bilingual subjects.

(2) The mean for the bilingual sample on the 'Conservation' part of the test was significantly higher than the mean for the monolingual sample. If the higher score implies that the concept is more advanced and more highly developed, the bilingual children manifest a better understanding of the concept when compared with monolingual children of the same age. Piaget and his collaborators have indicated that the age at which a child attains conservation is in part a function of the experience he has had. (Almy, 1966, p. 40). The bilinguals scored significantly higher. This evidence of higher mental functioning of the bilinguals would seem to demonstrate the importance of social interaction and social environment as ingredients of experience.

(3) The mean for the bilingual sample on the 'Measurement' part of the test was significantly higher than the mean for the monolingual sample. This suggests that the measurement concept, too, was developed to a more advanced stage in the bilingual subjects. This result, along with the previous one, shows that the differences in means for the two samples on the whole test can be attributed to the significant differences in means for both parts of the test. Thus, the advantage exhibited by the bilinguals is distributed over the whole test, and is not just due to any one part. This seems to imply that both the concept of conservation of length and the ability

to measure are developed to a greater extent in the bilingual children.

(4) Age was not a significant factor in predicting scores on the 'Concepts of Linear Measurement Test'. This result may seem to disagree with Piaget's (1960) and Towler's (1965) findings that the ability to deal with geometrical and spatial concepts increases with age. However, the subjects in this study attended grade one and their ages ranged from six years and two months to eight years and three months. This range is much smaller than the ones mentioned by Piaget and Towler. It is probable that the chronological age range was not large enough to produce any significant correlations between age and the test score, and that a greater age range would have produced results comparable with other investigators.

(5) Kindergarten attendance was not a significant factor in predicting scores on the 'Concepts of Linear Measurement Test'. Experience with the environment and social interaction are two of the four factors that explain the developmental process of thought. (Piaget, 1967)

According to Flavell (1963) it is social interaction which gives the ultimate 'coup de grâce' to childish egocentrism. It was assumed that the attendance of kindergarten or playschool represents a beneficial experience because it involves a unique socialization process. However, it did not appear among these children that kindergarten

attendance had much effect on the concepts studied here.

(6) Sex was not a significant factor in predicting scores on the 'Concepts of Linear Measurement Test'. This result is in agreement with those of Pelletier (1966) and Almy (1966). Pelletier found that no significant differences exist in the development of basic concepts of linear measurement between grade one girls and boys. Almy's data provided no evidence that the performance on the conservation tasks differs for the two sexes.

(7) Intelligence was a significant factor in predicting scores on the 'Concepts of Linear Measurement Test'. Almy (1966) reviewed several studies that related intelligence and results of Piagetian tests of concept formation. She concluded that the safest generalization one can make is that to some degree 'brightness' pays off. The findings of this study support the latter statement, and also the results of Pelletier's study (1966). He found that children with high mental ability were definitely more advanced in their development of the concepts of linear measurement than the children with low mental ability.

(8) Socio-economic status was not a significant factor in predicting scores on the 'Concepts of Linear Measurement Test'. Even though children from higher socio-economic levels scored higher, and the results approached significance, there is not enough evidence to support Almy's

(1966) finding. Almy's results showed that the rate at which conservation abilities occur differ for subjects with different socio-economic background. However, Pelletier (1966) found that the development of the concepts of linear measurement is not affected by differing socio-economic levels. It may be that Almy was working with more diverse socio-economic levels than is represented here or in the sample used by Pelletier.

III. IMPLICATIONS

The results of this study give rise to several implications:

(1) Research results (Bloom, 1964) show that the major part of intellectual development occurs during the period from birth to eight. It is during this time that experiences and environmental factors are most effective in contributing to the development of intelligence. The results of this study show that the introduction to a second language at an early age does not result in 'mental confusion' or inferiority of concept formation as is sometimes suggested. The opposite appears to be the case. If it is true that bilingualism increases intellectual potential and is beneficial to concept formation, then a second language should be introduced during these early years.

(2) Guilford (1959) talks about the existence of at least fifty factors of intelligence. According to him,

every one of these can be developed in individuals at least to some extent by learning. The results of this study seem to indicate that learning two names for every object and communicating in two languages speeds up the normal process of some parts of mental development. According to Peal and Lambert (1962) the speaking of two languages diversifies the intellectual structure. Teachers and administrators who deal with or instruct students who are bilingual should consider that these pupils could be advanced in the development of certain concepts and make provisions for curricular adjustments which would take such development into account.

(3) The advantage of the bilingual children in this sample over the monolingual children could be the result of many forces. Some of the obvious factors could be: an enriched cultural setting, improved social interaction, or the mental activities the young children participate in. It might be possible for educators or psychologists to design experiences which have some factors in common with the learning of a second language. These could be presented to children as a learning experience in school, or even before they enter school.

(4) The formation of a concept is a slow developmental process, and Piaget (1952, 1960) demonstrates this fact rather vividly. Conceptual thought gradually appears and develops during the pre-operational period. However,

basic concepts are organized into coherent systems once the child has reached the concrete operational stage. One of the most important components of the transition from pre-operational to concrete operational thought is the acquisition of various conservations. The results of this study seem to indicate that the bilingual children conserve length before the monolinguals do. If this is true for other conservations, it could be that bilingualism accelerates development, and the bilinguals reach the concrete operational stage before the monolinguals do. This of course would have important implications for those who teach in primary grades.

IV. SUGGESTIONS FOR FURTHER RESEARCH

Many questions arise as a result of the findings reported in this study. Some of these are presented below.

(1) According to the findings reported here, bilingualism is significantly related to the development of concepts of linear measurement when young children are considered. Does this relationship hold true for other concepts? Is it true for concept formation in general?

(2) The subjects used for this study were grade one children. Do older bilingual children possess any conceptual advantages over monolingual children? At what stage of the learning process does this advantage first appear?

(3) Concept formation represents a part of intellectual functioning. What is the nature of the effects of bilingualism on other aspects of intellectual functioning?

(4) The bilingual children who were used in this study were introduced to a second language in the home at a very early age. Does introducing a second language at a later age have similar effects? Would there be any favorable effects if a monolingual child is introduced to a second language in the school?

(5) Piaget's experiments show that the formation of a concept is a slow developmental process. It is a result of many interacting forces. If bilinguals are superior in acquiring concepts, what effect does this have on 'passing through the developmental stages' as they are outlined in Piaget's theory? For example, do bilingual children reach the stage of formal operations before monolingual children?

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A P P E N D I C E S

APPENDIX A

'CONCEPTS OF LINEAR MEASUREMENT TEST'

Subtest 1: Reconstructing Relations of Distance

Materials: 2 five and one-half inch trees,
1 three inch can,
1 screen twelve by eight inches,
1 block one and one-half by three and one-half by twelve inches.

(1) Place the two trees twenty-five inches apart. Place tree (B) on the can.

"Tell me, ______ (name of subject), is it farther from this tree (A) to that tree (B), or is it farther from that tree (B) to this tree (A) or is it the same?" or "Is it as far from here to there (A to B) as from there to here (B to A)?" (Investigator moves finger in appropriate direction.)

"Are the trees near or far apart?"

(2) Place the screen between the trees.

"Tell me, are the trees closer together now, farther apart now, or are they the same as they were before?"

"How do you know?"

(3) Remove the screen and place the block between the trees.

"Tell me, are the trees closer together now, farther apart now, or are they the same as they were before?"

"How do you know?"

Subtest II: Conservation of Length

Materials: 1 ten inch stick,
1 piece of string - fifteen inches long.

(4) Place the stick and an undulating piece of string side by side on a table so that their extremities coincide.

"Tell me, ______ (name of subject), which is longer, the stick, the piece of string, or are they both the same?"

"How do you know?"

(5) Extend the piece of string.

"Tell me, ______ (name of subject), which is longer, the stick, the piece of string, or are they both the same?"

"How do you know?"

(6) Return the string to its original shape (as in Item 4).

"What about now?" or "Tell me, which is longer, the stick, the piece of string, or are they both the same?"

"How do you know?"

Subtest III: Conservation of Length with a Change of Position

Materials: 2 four inch Cuisenaire rods.

Place the rods side by side on the table with their extremities coinciding.

"Tell me, _____ (name of subject), which stick is longer, or are they both the same?"

"How do you know?"

(7) Push the rod that is closer to the child about one-half inch to the left.

"Tell me, which stick is longer or are they both the same?"

"How do you know?"

(8) Arrange the rods to form the letter 'T'.

"Tell me, which stick is longer or are they both the same?"

"How do you know?"

(9) Arrange the rods to form an acute angle.

"What about now?" or "Tell me, which stick is longer or are they both the same?"

"How do you know?"

Distractor:

(five smarties; three different colors)

"Are all the smarties the same color, or are they different? Pick up two smarties that are not the same color."

Subject is allowed to eat them.

Subtest IV: Conservation of Length with Distortion of Shape

Materials: 12 counting sticks (each two and one-half inches long),
2 strips of paper (each ten inches long and one-half inch wide),
1 pair of scissors.

Arrange the counting sticks into two parallel lines about one inch apart with six counting sticks in each. The two lines must be aligned to make equality obvious.

"Tell me, _____ (name of subject), which line of sticks is longer or are they both the same?"

"How do you know?"

(10) Re-arrange the line of sticks closer to the child to form a right angle. Break two sticks.

"Tell me, which line of sticks is longer or are they both the same?"

"How do you know?"

Place two strips of paper side by side with their extremities coinciding.

"Tell me, which strip of paper is longer or are they both the same?"

"How do you know?"

(11) Cut the strip of paper closer to the child into two approximately equal pieces.

"_____ (name of subject), are these two pieces of paper together longer, or is this strip of paper (uncut) longer, or are they the same?" (Investigator points

to appropriate pieces).

"How do you know?"

(12) Cut at an angle one of the two pieces cut previously in Item 11.

"Tell me, _____ (name of subject), are these three pieces of paper together longer, or this strip of paper (uncut) longer, or are they the same?"

"How do you know?"

Subtest V: Measurement of Length

Materials: A quantity of unmarked cardboard strips each one-half inch wide and two inches, four inches, and six inches long.
2 pieces of cardboard measuring fourteen by eighteen inches with the following pairs of one-half inch wide figures pasted on each:
(a) 2 right angles, one with arms two and six inches long, and the other with both arms four inches long.
(b) 1 obtuse angle with a fourteen inch arm and a two inch arm; and an acute angle having a six inch arm and a ten inch arm.

(13) "Look at these two lines." (Investigator traces the first pair), "Tell me, which line do you think is longer or are they both the same?"

"How do you know?"

"______ (name of subject), could you use any of these strips of cardboard to find out or show me if that line is longer?" (or "if they are the same" -- depending on subject's response to first question).

(14) "Look at these two lines." (Investigator traces the second pair).

"Tell me, which line do you think is longer or are they both the same?"

"How do you know?"

"Could you use any of these strips of cardboard to find out or show me if that the line is longer?" (or "if they are the same?")

Subtest VI: Subdividing a Straight Line

Materials: 2 straight nineteen and one-half inch rods each with a bead that is free to move along it;
3 sticks measuring three inches, ten inches, and nineteen inches.

Introductory Activity:

The two wires are placed on the table about one foot apart. They are slightly staggered and about parallel. One wire is assigned to the subject, the other to the investigator. Both beads are at the same end of the wire.

As the investigator moves his bead about four inches from one end, he says, "I would like you to take your bead and move it just as far along the wire as I move mine."

"How do you know they are the same? Could you use any of these sticks to find out if you have moved your bead just as far as I have moved mine?" or "Could you show me any other way?"

Similarly for questions 15, 16, 17, and 18.

(15) Place the two wires in exact alignment with one bead at the extreme left and the other at the extreme right. "Take your bead and put it as far from this end (right) as I am going to put mine from this end (left).

"I take my bead and put it this far (about four inches). I want you to do the same," or "How far are you going to move yours?"

(16) Push the wire farthest from the child about five inches to the left. Place the two beads at the extreme left of the wires.

"Take your bead and put it as far from this end (left) as I am going to put mine from this end (left)."

"I take my bead and put it this far (about four inches). I want you to do the same."

(17) Leave the wires in the same position as for Item 16. Place one bead at the extreme left of one wire and the other bead at the extreme right of the other wire.

"Take your bead and put it as far from this end (right) as I am going to put mind from this end (left)."

"I take my bead and put it this far (a little more than fourteen inches). I want you to do the same."

(18) Arrange the two wires to form an acute angle so that their extremities are not aligned. Place one bead at the extreme left of one wire and the other bead at the extreme right of the other wire.

"Take your bead and put it as far from this end (right) as I am going to put mine from this end (left)."

"I take my bead and put it this far (about fourteen inches). I want you to do the same."

APPENDIX B

SCORE SHEET

School______________________________ Grade________

Name: ________________________

Sex: M_____ F_____

Birthday:________________19__

Occupations:
Father________________________
Mother________________________

Kindergarten: Yes___ No ___

I.Q.__________ (test________)

Text:________________________

Monolingual__________________

Bilingual____________________

Subtest 1

1. A-B B-A
   same near far 1.______
2. closer-farther-same 2.______
3. closer-farther-same 3.______

Subtest 2

4. stick string same 4.______
5. stick string same 5.______
6. stick string same 6.______

Subtest 3

(longer-same)

7. longer (TB) same 7.______
8. longer (TB) same 8.______
9. longer (TB) same 9.______

Subtest 4

(longer-same)

10. longer (TB) same 10.______
11. longer (TB) same 11.______
12. longer (TB) same 12.______

Subtest 5

correct measure;

13. longer same Y N 13.______
14. longer same Y N 14.______

Subtest 6

correct measure:

15. same - yes / no Y N 15.______
16. same - yes / no Y N 16.______
17. same - yes / no Y N 17.______
18. same - yes / no Y N 18.______

TOTAL: __________

Comments:

Questions: 7 - 12: T-top, B-bottom.
13 - 18: Y-yes, N-no.